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Van Sangyan

Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

by e-mail to vansangyan_tfri@icfre.org

or, through post to The Editor, Van Sangyan,
Tropical Forest Research Institute,
PO-RFRC, Mandla Road,
Jabalpur (M.P.) - 482021.

The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number. TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve

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From the Editor's desk

The dependency of many Indian rural households on natural resources for sustenance is widely acknowledged. Under the difficult climatic situations, farmers are forced to adopt tree-based systems to secure their income and livelihood. Natural resources provides food, fresh water and timber products. Madhuca longifolia is one the important non timber forest tree in forest and urban areas; it's commonly called as Mahua. Flowers and fruits are used as food and also in preparation of value added products such as Laddu, jam, pickle and sold in local market. Flowers are rich source of sugar, protein, vitamin and minerals. From the seed, oil is extracted for cooking, lighting, biodiesel, laundry soaps, and detergents and also used in medicinal field. Seed oil contains sapogenins, triterpenoids, steroids, saponins, flavonoids and glycosides.

In line with the above this issue of Van Sangyan contains an article on महुआ के उपयोग के लिए वर्तमान स्थिति और भविष्य की संभावनाएं, There are also useful articles viz. Fire detection and management in India, Mangrove ecosystem, The role of seed banks in plant conservation, शहतूत (मोरस अल्बा) की खेती के तरीके, Tree root system architecture studies: Relevance in forestry and agroforestry, Genetic diversity in Balanites Aegyptiaca (Soapberry Tree) – A prospective tree to augment wide array of economic and ecosystem services in major Indian ravines, Rhizobacteria: unveiling the key players in nutrient cycling and soil fertility, An industrial perspective on bamboos, and Role of artificial intelligence in forest conservation.

I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests. Van Sangyan welcomes articles, views and queries on various such issues in the field of forest science.

Looking forward to meet you all through forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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महुआ के उपयोग के लिए वर्तमान स्थिति और भविष्य की संभावनाएं

धर्मेन्द्र कुमार गौतम[1*], विकाश कुमार[1], सिद्धार्थ कुमार[1], ओम प्रकाश[1], सत्येंद्र वर्मा[1], मिलिंद सागर[2] और मणि प्रकाश शुक्ल[3]

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परिचय

महुवा (मधुका लोंगिफोलिया) एक बहुगुणी पेड़ है जो स्थानीय लोगों को विभिन्न प्रकार के उत्पाद देता करता है , साथ ही साथ कई जीवों के लिए खाद्य उत्पाद भी बनाती है । महुआ का पेड़ मध्यम से बड़े आकार के जिनमें अच्छी वृद्धि होती है। पेड़ 8 से 15 साल में परिपक्व होकर फूल और फल देना शुरू कर देता है । महुआ के फूल पसीने की गंध वाले होते हैं तथा शाखाओं के सिरे पर गुच्छों में दिखाई देते हैं । फल अंडाकार होते हैं जो लंबे बीजों से घिरे होते हैं और वे भूरे और चमकदार होते हैं । महुआ में फूल फरवरी से अप्रैल तक आते है, यह स्थानीयता पर निर्भर करता है । यह एक अस्थायी अनुक्रम दिखाता है , शीर्ष भाग से निचली शाखाओं तक और रोशनी वाले भाग से पेड़ के छायांकित भाग तक अधिक फूल आते है। फलों का पकना मई-जुलाई में होता है । हालाँकि जब फेनोलॉजिकल चरणों का संबंध होता है तो पेड़ से पेड़ की बहुत भिन्नता देखी जाती है। उदाहरण के लिए दक्षिणी भाग की तुलना में उत्तरी गुजरात में फल जल्दी पक जाता है । प्रजातियां प्रायद्वीपीय भारत के उत्तरी , मध्य और दक्षिणी भाग में वितरित की जाती हैं ।

महुआ वन और गैर -वन क्षेत्रों दोनों में देखा जा सकता है । हमारे क्षेत्र के अवलोकन से पता चलता है कि यह महुआ जंगल के पास रहने वाले लोगों के लिए आजीविका के महत्वपूर्ण विकल्पों और आय सृजन के स्रोतों में से एक है । जनजातियों सहित स्थानीय लोग फूल , फल और बीज जैसे विभिन्न महुआ संसाधनों के संग्रह में लगे हुए हैं । आदिवासी इन उत्पादों का भरपूर उपयोग कर रहे हैं । उम्र और लिंग के परे लोग

ज्यादातर महुआ संसाधनों के संग्रह और फूल और फलने के मौसम के दौरान इसके उपयोग में शामिल होते हैं।

महुआ के फूल का उपयोग

देश में महुवा के फूलों की कुल उपज प्रति वर्ष लगभग पंद्रह से बीस लाख टन होने का अनुमान है । इनमें से अधिकांश का उपयोग या तो घरेलू उद्देश्य के लिए किया जाता है या स्थानीय बाजार में बहुत कम कीमतों पर बेचा जाता है । सूखे महुआ के फूलों का उपयोग विभिन्न किण्वित उत्पादों (अल्कोहल, लैक्टिक एसिड और एसीटोन) चाशनी के उत्पादन में किया जाता है । महुआ के फूल से शराब का उत्पादन हमारे देश में सदियों से चली आ रही परम्परा है । इसके अलावा इस उत्पाद का अधिकांश हिस्सा घरेलू उपयोग तक ही सीमित है और लोगों को कोई आर्थिक लाभ नहीं दे रहा है । महुआ, उच्च आर्थिक मूल्य का एक स्वदेशी पेड़ होने के कारण , इसमें अच्छी गुणवत्ता वाली शराब की विशाल क्षमता है, जिसे व्यापक निर्यात बाजार मिल सकता है । महुआ के प्रामाणिक किण्वित उत्पादों को व्यवस्थित तरीके से तैयार करने के बारे में कुछ वैज्ञानिक रिपोर्टें हैं । महुआ शराब /शराब का सबसे अच्छा स्रोत हो सकता है क्योंकि महुआ के फूल कई खनिजों के अलावा चीनी (68-72%) से भरपूर होते हैं । अबयह सोचने का समय है कि भारत में लोग फ्रेंच , स्पेन, अर्जेंटीना वाइन और अंग्रेजी स्कॉच क्यों पसंद करेंगे , जब हमारे देश में महुआ जैसी ताजा और कायाकल्प करने वाली चीज उपलब्ध है? महुआ में काफी क्षमता है और इसे एक उद्योग के रूप में विकसित किया जा सकता है जैसे कि महाराष्ट्र सरकार ने शराब के लिए अंगूर का इस्तेमाल किया है या गोवा ने फेनी के लिए काजू का इस्तेमाल किया है । आदिवासी लोगों और वनवासियों को लगातार महुआ एकत्र करने की अनुमति दी जानी चाहिए , उनका उचित बाजार में व्यापार किया जाना चाहिए, लेकिन स्थानीय अवैध आसवन पर रोक लगाई जानी चाहिए । हालाँकि, इस प्रकार तैयार किया गया पेय निम्न गुणवत्ता का होता है और कभी-कभी ठीक से तैयार न होने पर स्वास्थ्य के लिए हानिकारक होता है । अवैध शराब बनाने और बैटरी तरल पदार्थ और अन्य जहरीले पदार्थों के साथ पेय को किक देने के लिए इसे और भी खराब कर दिया है । दूसरा नुकसान यह है कि इसमें ज्यादातर अल्कोहल होता है । जब इस प्रकार के उत्पादों का व्यावसायीकरण किया जाता है, तो इस बात की काफी संभावना होती है कि संग्राहकों को बेहतर कीमत मिलेगी और प्रजातियों का संरक्षण और देखभाल की जाएगी। गार्सिनिया इंडिका (कोकम) फलों के मामले में पहले कीमत 35-40 रुपये प्रति किलो थी। पिछले चार से पांच वर्षों में कोकम जूस , कोकम सिरप और कोकम खजूर जैसे मूल्यवर्धित उत्पाद लोकप्रिय हो गए हैं। व्यावसायीकरण के परिणाम ने किसानों को बड़े पैमाने पर इस फसल को लेने में मदद की और 60 रुपये प्रति किलोग्राम से अधिक कीमत 100 रुपये प्रति किलोग्राम तक प्राप्त करने की उम्मीद की । स्थानीय स्तर पर फूलों को सुखाकर सीधे खाया जाता है और कभी-कभी सूखे फूलों का उपयोग आदिवासी समुदाय द्वारा तैयार स्थानीय मिठाई में किया जाता है। ऐसा माना जाता है कि यह तुरंत ऊर्जा प्रदान करता है और दुबलेपन की अवधि में एक अच्छा पूरक है। महुआ के फूल शरीर , आंखों को ठंडक देने के लिए भी अच्छे माने जाते हैं और दमा, रक्त रोग, प्यास और जलन के साथ -साथ टॉनिक के

रूप में भी इस्तेमाल किए जाते हैं । हाल के अध्ययनों से पता चला है कि महुआ के फूलों से केक, जैम, जेली, जूस, सॉस और कन्फेक्शनरी जैसे विभिन्न प्रकार के मूल्यवर्धित उत्पाद तैयार किए जा सकते हैं।

महुआ बीज का उपयोग

हमारे देश में घरेलू और अंतरराष्ट्रीय बाजार में मौजूदा मांग की तुलना में कच्चे तेल और प्राकृतिक गैस का घरेलू उत्पादन कम है । मांग और आपूर्ति के बीच बहुत बड़ा अंतर है जो वर्तमान में आयात से पूरा किया जाता है , जिसके परिणामस्वरूप देश पर विदेशी मुद्रा का भारी बोझ पड़ता है । पेड़ आधारित तेल से बायोडीजल का उत्पादन देश में डीजल का सबसे अच्छा विकल्प माना जाता है । महुआ के पेड़ को उनके बीजों के लिए महत्व दिया जाता है जो व्यावसायिक रूप से महुआ मक्खन के रूप में जाना जाने वाला वसायुक्त तेल पैदा करते हैं । महुआ तेल के बायोडीजल उत्पादन में संभावित उपयोग की सूचना है । महुआ के बीजो को सूखा के उससे गिरी बनाया जाता है । महुआ की गिरी से निकाले गए तेल की मात्रा गिरी की गुणवत्ता (वजन, सूखापन, स्वास्थ्यप्रद आनुवंशिक गुणवत्ता, आदि) और तेल निकालने की विधि के आधार पर 20 से 43% तक होती है । गुणवत्ता वाले बीजों के बड़े पैमाने पर उत्पादन के लिए महुआ के अच्छे जीनोटाइप की पहचान और स्क्रीनिंग आवश्यक है । भारत में, महुआ का तेल मुख्य रूप से घरेलू खाना पकाने के लिए उपयोग किया जाता है । लोग स्थानीय घानियों में पीसकर स्थानीय रूप से तेल निकलते और इसे अपनी दैनिक जरूरतों के लिए उपयोग करते है। कच्चे महुआ के तेल में स्वाद में कुछ कड़वाहट होती है , हालांकि महुआ के बीज के तेल से कड़वापन दूर करने के तरीके भी हैं । कड़वाहट दूर करने का यह पारंपरिक ज्ञान बहुत ही सरल और लोग कई पीढ़ियों से अपने प्रयोगों और अनुभव से इसका पालन कर रहे हैं । इसके अलावा, पेड़ को आदिवासी संस्कृति में बहुत सम्मान मिला है और लोग पारंपरिक रूप से इन बहुउपयोगों के बारे में जानते हैं । इसलिए यह प्रजाति जैव-ईंधन का एक अच्छा स्रोत बनने की क्षमता रखती है।

महुआ संसाधनों से जुड़े जोखिम

महुआ की अधिकांश आबादी में पेड़ काफी पुराने हो चुके हैं। हालांकि पेड़ अच्छी मात्रा में व्यवहार्य बीजों का उत्पादन करते हैं , लेकिन स्थानीय लोगों द्वारा बीजों के पूर्ण संग्रह के कारण प्राकृतिक पुनर्जनन की दर बहुत कम है । कई क्षेत्रों में, आसान संग्रह की सुविधा के लिए , हर साल लोग महुआ के पेड़ों के आस -पास के क्षेत्र को जला देते हैं जो पुनर्जनन को नष्ट कर देते हैं । थोक में फूल और बीज दोनों का संग्रह करने से महुआ की उपज की गुणवत्ता खराब हो सकती है । चूंकि एकत्र किए गए बहुत से फूलों और बीजों को क्षतिग्रस्त , सड़ा हुआ और घटिया गुणवत्ता वाला माना जाता है । इसके अलावा यह अंतिम कीमत और बाजार मूल्य को प्रभावित करता है । वर्तमान में महुआ संसाधनों के भंडारण और प्रसंस्करण के लिए स्थानीय स्तर पर बहुत कम काम या सुविधा उपलब्ध है । महुआ संसाधनों में मूल्यवर्धन की काफी गुंजाइश है। भले ही गुजरात और मध्य प्रदेश में महुआ उत्पादों के लिए सरकार द्वारा एक अच्छी विपणन सुविधा प्रदान की जाती है, फिर भी फूल और बीज स्थानीय साप्ताहिक बाजार में बेचे जाते हैं , कभी-कभी छोटे व्यापारी इन संसाधनों को सीधे अपने घरों से बहुत कम कीमत पर एकत्र करते हैं।

भविष्य की संभावनाएं

महुआ के पेड़ों और उनके पारिस्थितिकी तंत्र को होने वाले नुकसान को नियंत्रित करने के लिए , मजबूत कानून और संरक्षण उपायों की आवश्यकता है । अच्छे जीनोटाइप को बनाए रखने के लिए जमीन को जलाने से महुआ संसाधनों का संरक्षण और पूर्ण संग्रह समय की आवश्यकता है । महुआ संसाधनों के संरक्षण और सतत विकास के लिए वैज्ञानिक हस्तक्षेप बहुत आवश्यक है । स्थानीय स्तर पर बाजार को इस तरह मजबूत करने की जरूरत है कि किसान को उचित मूल्य मिले । महुआ संसाधनों का अधिक कुशल तरीके से उपयोग करने के लिए भंडारण , प्रसंस्करण और मूल्यवर्धन सुविधाएं सुलभ निकटता पर प्रदान करने की आवश्यकता है। संरक्षण, सतत संग्रह, विपणन और कटाई के बाद के उत्पादों पर स्थानीय लोगों के लिए जागरूकता और प्रशिक्षण कार्यक्रम देश में महुआ आबादी की आजीविका सुरक्षा और सतत विकास प्रदान करेंगे।

Fire detection and management in India

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Forests are known as the lungs of the planet and host nearly 75% of the world's terrestrial biodiversity. Nearly half of the tropical forests have been destroyed since the 1960s. This may be due to natural or man-made disasters. Forest fire, also known as wildfire, is one of those disasters causing an imbalance in nature and posing threats to flora and fauna thereby disturbing the biodiversity of the area. Forest fires are increasing in the present scenario; it is a major problem in the biosphere-atmosphere interface. It has an effect on the atmosphere's gaseous composition, biochemical cycling, and forest ecosystem. Emissions from forest fires can increase the actual amount of carbon and nitrogen and aerosol released from forest fires can affect the formation of clouds.

A forest fire may be defined as unclosed and freely spreading combustion that consumes the natural fields. Forest fire has become a recurrent phenomenon in last 30-40 years. In total about 55% of the forest area is prone to forest fires in India and over 2,00,000 forest fire incidences are reported annually (Mahmoud, 2018). Forest fires are classified into three different categories namely Ground fires, Surface fires and crown fires. Ground fires are more common in areas with dense vegetation. On the height of the Himalayan fir and spruce woods, such flames may be observed in a completely odd way. Surface fires: they start on or close to the bottom cover or the floor in a cluster. The main locations that are not unusual at all woodlands are prone to flames are cleaning and renovation. Crown fires: Fires that start inside a tree's crown consume its leaves and frequently destroy the tree. Among the Siwaliks and the Himalayan Forest, a low coniferous forest region often sustains the most damage (NCA Report, 1976).

Scientific community is performing several environmental studies since many years, discovering new technologies, applying them, and modifying them to adopt the best. Usually, four steps are involved in forest fire evaluation and management which includes mapping risks and hazards which have the potential to detect forest fire, detecting forest fire hot spots (areas with greater availability of potential raw materials like deciduous forests with more dry leaf litter during summer season), monitoring of active fires (using different sensors) and assessing post-fire degradation and including better management practices. Risk assessment is crucial since it helps to understand where

the forest is most at danger of fire (Roy, 2003).

Need of forest fire management

Forest fires adversely effects animals not only by killing them but also by long term effects such as stress, habitat loss, territories, shelter & food. The loss of key organisms in forest ecosystem, such as invertebrates, pollinators and decomposers will slow the recovery rate of forest (Boer, 1989). Forest fire management is the process of gathering previous data, modifying detection techniques, preventing fires and protecting flora and fauna. FSI is monitoring forest fires in our country which requires a high degree of coordination between strategic fire centers, ministries, funding, human resource development, fire research, fire management and extension programs for proper and systematic management of forest fire. This management system helps in guiding humans and making them aware of their activities which can cause threats to both nature as well as mankind (FSI report, 2019).

Successful fire management depends on effective fire prevention, detection, and pre- suppression, having an adequate fire suppression capability, and consideration of fire parameters relationships. By using the fire modeling and risk assessment tools to predict, to minimize both direct and indirect losses caused due to fire. Risk assessment is a major task in any framework developed for fire safety management (Verma, 2017).

Forest fire scenario in Global and national level

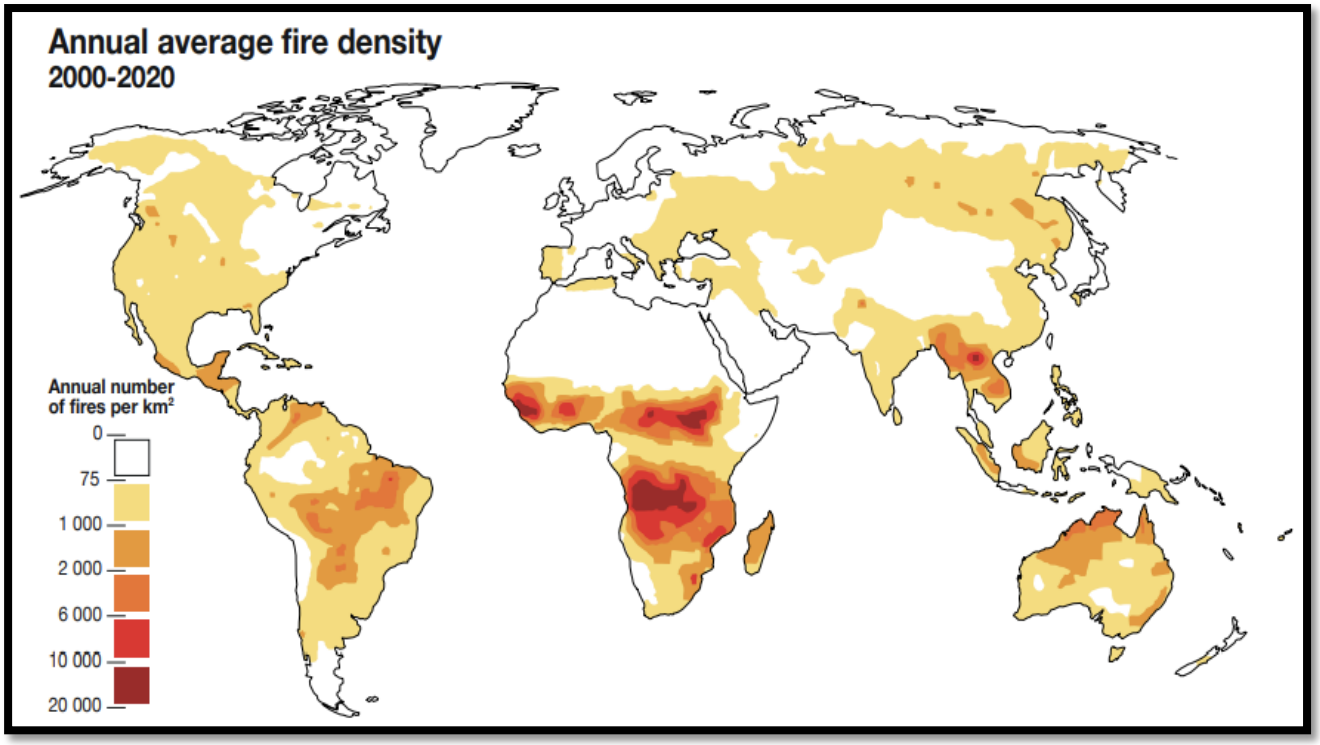

Figure 1- This figure shows the annual concentration of all vegetation fires observed per km^2 (UNEP Rapid Response Assessment, 2022).

Forest fires affects the global forest nearly around 98 million hectares of forest land, which is around 4% of actual forest cover in 2015. More than two-thirds of the total forest area affected was in Africa and South America.Every region of globe is detected by sensors, however 80% of detected fires were in Africa. The mainly savanna woodlands were effed. Human were responsible for the more than 75% of global wildfires, the incidences of fire was increased from 2019 to 2020 by 13% (WWF, 2020).

National level

India is the country with good diversity of forests with the total forest cover of 7, 13,739 square kilometres which is 21.71% of country geographical area (FSI, 2021). But the forest frequently faces threats of wildfires and other anthropogenic activities. Most of wild animals and biodiversity of the area are affected because of the forest fires. More frequent fires occur in the dry deciduous forest as comparable to semi-evergreen, or evergreen forest (Sharma et al. 2012).

In India, Ministry of Environment, Forest and climate change department has analysed the fire status in India as a part of management of forest fires. Forest Survey of India had worked on forest fire status in India. Fire risk zonation stared from 2004 to 2021 on the basis of spatial analysis, 10.66% of Indian forest was under the extreme to very high prone to forest fire. Few states of northeast India show extreme fires attacks, they were like Mizoram, Tripura, Meghalaya, and Manipur. Few parts South India and Central India were very highly fire prone areas such were parts of Western Maharashtra, Southern part of Chhattisgarh, Central Part of Odisha and few parts of Andhra Pradesh, Telangana and Karnataka. Table: 1 presents the Forest cover in different fire prone or susceptible zones.

Table: 1 -Forest cover in different fire prone zones (ISFR Report, 2021).

S.No.	Fire prone zone category	Percentage of total forest cover
1.	Extremely fire prone	2.81%
2.	Very highly fire prone	7.85%
3.	Highly fire prone	11.61%
4.	Moderately fire prone	13.19%
5.	Less fire prone	64.54%
	Total	100%

The Ministry has come with new plan such as National Action Plan on Forest Fires, 2018 to renew the forest fire management system, empower the forest fringe communities and also incentivize the work with state forest department (ISFR Report, 2021).

Forest fire monitoring in India

Satellite data with great temporal repeatability, spectrum diversity, and vast spatial coverage has made monitoring these fires much easier. International organisations such as NOAA (National Oceanic and Atmospheric Administration), NASA, and satellites such as Terra and Aqua, IRS P4 (OCEANSAT), IRS P6-AWiFS (Indian Remote Sensing - Advanced Wide Field Sensor), and SPOT-VGT (Système Pour l' Observation de la Terre-Vegetation) are being used to track

fire occurrence, fire progression, and damage assessment.

Using the latest remote sensing and communication technology, the Indian Forest Survey has been aiding state forest departments and other organisations in dealing with the difficulties related with forest fire since 2004.Currently FSI is alerting state forest departments towards forest fire incidences detected by MODIS (moderate resolution imaging Spectro – Radiometer) sensor on board Aqua and Terra satellites of NASA and SNPP VIIRS (Suomi National Polar-orbiting Partnership (***SNPP***) Visible Infrared Imaging Radiometer Suite) sensor at least six times in 24 hours. The fire hotspots detected by these sensors are received at National Remote Sensing centre and processed using standard algorithm. The fires hotspots are electronically shared with FSI, which are further processed automatically at FSI headquarter and alerts are generated and disseminated to the registered end users as SMS (ISFR 2021).

Analysis of number of forest fire detected using MODIS & SNPP-VIIRS sensors for fire seasons 2019-2020 and 2020-2021

During the forest fire season 2019-2020, the number of hotspots detected by MODIS sensor were 22,447 & by SNPP-VIIRS sensor were 1, 24,473. In fire season 2020-2021, the total hotspots detected by MODIS sensor were 52,785 & by SNP-VIIRS sensor were 3, 45,989.

Amongst States, maximum number of fire detections were observed in Odisha (51,968) followed by Madhya Pradesh (47,795) and Chhattisgarh (38,106). Amongst districts, maximum number of SNPP-VIIRS forest fire detections were observed in Gadchiroli in Maharashtra (10,577) followed by Kandhamal in Odisha (6,156) and Bijapur in Chhattisgarh (5,499). According to FSI's long-term trend research, almost 10.66 percent of India's forest cover is in an extremely-to-extremely fire-prone zone. States in the North-Eastern region have the highest risk of forest fire, and these states are located in a high-risk forest fire zone. In the North-Eastern part of India, states like Mizoram, Tripura, Meghalaya, and Manipur have the highest forest fire hazard in terms of frequency of occurrence. Western Maharashtra, southern Chhattisgarh, central Odisha, and a few portions of Andhra Pradesh, Telangana, and Karnataka have patches of very and very highly fire prone zones (ISFR 2021).

Major satellite systems used for fire assessment from global to local scale

Sensor	Major application	Spatial resolution	Swath width	Bands (lm)
BIRD	Active fire detection and burnt area assessment	185 m	190 km	**MIR 3.4–4.2 TIR 8.5–9.3**
MODIS	Active firedetection and burnt area assessment	250 m 500 m 1 km	2,330 km	**36 bands including 3.9 And 11 lm**
AVHRR	Active fire detection and burnt area assessment	1.1 km	2,400 km	**0.58–0.91 10.3–12.9**

DMSP-OLS	Active fire detection	0.56 km	3,000 km	**0.58–0.91**
GOES–10&12	Active fire detection	1 km 4 km 8 km	Hemisphere	**0.55–0.75** **3.80–4.00** **6.50–7.00** **10.20–11.20** **11.5–12.5**
ATSR	Active fire detection and burnt area assessment	1 km	500 km	**3.51–3.89** **1.57–1.63** **10.4–11.3** **11.5–12.5**
IRS-AWiFS	Active fire detection, burnt area assessment and validation.	56 m	370 km	**0.52–0.59,** **0.62–0.68** **0.77–0.86,** **1.55–1.70**
LandsatTM andETM	**Active fire detection, burnt area assessment and validation**	**30 m**	**185 km**	**0.45–0.52,** **0.52–0.60** **0.63–0.69,** **0.76–0.90** **1.55–1.75,** **10.4–12.5** **2.08–2.35**

Significance of GIS in forest fire management

With advancing tools and technologies in this modern era, new methods have been adopted for a more precise and automatic way of monitoring forest fire and their management using wireless sensors based on geographic information system (GIS) which is equipped with innovative extinguishing and detection technology. These methods of GIS on fire detection proved to be quite effective but sometimes there was a generation of false alarms caused mainly due to user errors (Mahmoud, 2018). In order to overcome this problem, we are using a combination of different sensors like AWiFS, LISS III, ETM+, SPOT, AVHRR and MODIS (Saranya et al. 2014). For example, the use of a smoke detector along with remote sensing techniques because the first visible sign of combustion is the emission of smoke and a smoke detector can easily detect forest fires based on features like temperature, humidity, air transparency, flame smoke color, etc. and also helps in overcoming the problem of false alarms (Podrzaj and hanmotto, 2008).

Fire detection and management in India

A study was conducted by Chandra (2005) on the application of remote sensing and GIS technology in forest fire risk modelling and management of forest fires in the Garhwal Himalayan Region where they developed a central level sector plan that includes- Early development Forest fire warning, mapping of affected forest areas, development of fire hazard types, tracking the affected area and its evaluation, identification, and mapping of

all fire-hazardous areas and zonation of fire risk area is carried out based on various parameters such as fuel load, slope, aspect, altitude, drainage, distance from roads and settlements. These parameters were assigned with different weightages depending upon their impact. Thus, high to low fire risk zones can be identified and suitable management strategy for controlling the disaster can be prioritized while Sowmya and Somashekar (2010) used AHP model for mapping of forest risk zone at Bhadra wildlife sanctuary. They identified the factors which are influencing the fire such as vegetation, slope, distance from roads, settlements were derived by using topographic maps and field information and weightage was assigned according to their influence on forest fire.

A study by Mantra (2011), states that the fuel moisture content which was released by the forest fire, helps in detection of fire hazard on the environment by using NDVI index taken from the AVHRR sensors. The emergency responses in the forest fire area had been carried out based on this FMC estimation. Spatial and the temporal patterns were evaluated by Verma et al. (2017) for monitoring forest fire changes in the Mudumalai tiger reserve by using GIS. For this study, they used Landsat thematic maps, enhanced thematic maps and all previous data were collected from the State Forest department and calculated the Mean burned area and fire return interval for forest types. Ahmad and Goparaju (2017) have done on the assessment of forest fires in Jharkhand by grid analysis in the districts of Palamu and Singbhium. They used the district boundary maps which were taken from the DIVA GIS softwarefusing grid analysis. Previous forest covers maps taken from FSI. Then 2 km × 2 km grid was generated to evaluate each grid with reference to forest fire incidence. It provides a spatial view of forest fire occurrence, spread over duration of time. Kanga and Singh (2017) were carried out a study for forest fire spread analysis and loss assessment using simulation modeling techniques in Jaipur. They took consideration of parameters like forest types, canopy cover, meteorological status, topographic features. They used FARISTE (fire area stimulator) for forest fire simulation model and used to determine the fire behaviour with parameters, and then they prepared fire spread maps and detected the fire areas. This study found out the fire spread and direction based the climatic factors.

Conclusions

Increasing the present population were leads to major stress on the biological resources and due to that some anthropogenic activities lead to huge losses of a forest fire. In this current situation, we need to conserve, protect that forest resources by managing and protecting the resources. So, need to be concerned about the forest fire mapping and assessment of it risk by index method, visual analysis methods etc. Based on this fire detection methods improvisation in forest techniques, fire fighting equipment and resources and schedule. By using the basic technique like making forest lines, the establishment of watch towers by checking the location in Forest fire risk map. Remote sensed data is used along with the GIS techniques.

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Mangrove ecosystem

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Introduction

Mangroves are plant communities that can withstand salt that have developed in tropical, intertidal areas of the world. These regions are characterised by heavy rainfall (1000-3000 mm) and temperatures between 250 and 350 °C. They are composed of taxonomically varied shrubs and trees that are found across tropical and subtropical climes in habitats including shorelines, estuaries, tidal creeks, backwaters, lagoons, marshes, mudflats, and even upstream locations where the water is still salty (Qasim, l998). As they provide significant ecological supplies and services to human society as well as coastal and marine systems, mangroves are among one of the most productive ecosystems in the world (Bouillon 2003; FAO, 2007). There are 55 species of true mangroves in India and majorities are coming under the families Acanthaceae, Avicenniaceae, Meliaceae and Rhizophoraceae (Vidyasagaran and Gopikumar, 2006). The total extent of mangroves has been classified in to 3 groups as 'Major mangroves,' Mangrove associates,' and 'Back mangal'.

The mangrove may reach heights of around 9 metres (30 ft). The leaves of mangroves are thick, have leathery surfaces, and are grown on short stems. They are opposite, 5 to 15 cm (2 to 6 inches) long, oval or elliptic, and smooth-edged. Pale yellow describes the blooms. The long embryonic root originates from the seed and grows quickly downward while the fruit is still affixed to the parent branch. The juvenile root is in the ideal position to be pushed into the mud when this propagule falls, and after the plant is planted, the shoot emerges.The Indo-Malaysian area can be regarded as the origin of mangrove vegetation since it has the highest diversity of mangrove species (Chapman, 1975). There are between 60 and 100 species of mangroves worldwide, which are divided into more than 30 genera and 20 distinct families (Singh et al., 1987). Mostly found in Bangladesh, India, Indonesia, Pakistan, Sri Lanka, and the Philippines (Naskar and Mandal, 1999). Mangrove vegetation may be found in India's coastal states of Maharashtra, Gujarat, Orissa, Goa, Andhra Pradesh, Tamil Nadu, Karnataka, and Kerala (MoEF, 1987).

Adaptations of mangroves

The mangrove ecosystem is extremely important and strong. The species have developed several adaptations to cope with these harsh environmental circumstances. Aerial roots, viviparous embryos, tidal dispersal of propagules, rapid rates of

canopy production, absence of growth rings, wood with narrow, densely spaced vessels, a highly effective nutrient retention mechanism, tolerance to salt, and the ability to maintain water and carbon balance are morphological and physiological traits for adaptation (Naskar and Palit, 2015)

Breathing roots

Oxygen for the purposes of respiration is needed by the underground tissue of any plant. As far as the mangroves are concerned, oxygen in the soil is in very limited supply. This means that the mangroves take up oxygen from the atmosphere. For this purpose, mangrove species have specialized above ground roots called breathing roots or pneumatophores. These roots have numerous pores through which oxygen enters into the underground tissues. In some plants buttress roots function as breathing roots and also provide mechanical support to the tree.

Stilt roots

In some mangrove species, roots emerge from stems and branches. Such roots get into the soil some distance away from the main stem as in the case of banyan trees. These stilt roots are endowed with many pores through which atmospheric oxygen enters into the roots.

Vivipary

It is postulated that "saline water, unconsolidated saline soil with little or no oxygen is not a conducive environment for seeds to germinate and flourish. To overcome this, mangrove species have a unique way of reproduction, which is generally known as vivipary". This is a very unique method of reproduction. In this method, seeds germinate and develop into seedlings while the seeds are still attached to the parent tree. These seedlings are normally known as propagules. They photosynthesize while still attached to the mother tree. The parent tree supplies water and necessary nutrients. They remain buoyant and float in the water for some time before rooting themselves on suitable soil.

Larger vacuole

This vacuole for storage of salts is one of the main mechanisms in salinity tolerance (Munns and Tester 2008). Stresses imposed by salinity influence leaf anatomical and stomatal features to a greater degree than phylogenetic relationships (Baumel et al. 2002).

Uses

Mangroves physically act as a barrier between marine and terrestrial populations and defend coastlines from wind, wave, and flood damage. Mangrove thickets minimise coastal erosion, play a vital role in recycling nutrients, enhance water quality by filtering contaminants and trapping sediments from the land, etc. Ecologically speaking, they support a wide variety of terrestrial creatures, and several species of coastal and offshore fish and shellfish exclusively breed, spawn, and hatch in mangroves. Mangroves are frequently among the first species to colonise mud and sand banks in undated by seawater because of their high salt tolerance, but a surge in coastal development and changing land use resulted in a drop in worldwide populations.

Mangroves have a sophisticated root system that is particularly effective in absorbing the force of waves, preventing tsunamis, storm surges, and soil erosion in

coastal locations. Their defensive function has been widely acknowledged, particularly in the wake of the 2004 tsunami's devastation. In West Bengal, the Sundarbans act as a flood barrier. Water flows are reduced by mangrove roots, which also promote silt deposition. Because of the retention of fine sediments, including heavy metal pollutants, they therefore function as a zone of land accretion. Moreover, they stop seawater contamination and coastline erosion. Mangroves have intricate structural features and a variety of habitats. They thereby provide distinctive settings that act as niches for a wide range of creatures. They provide a vital source of income for coastal communities who depend on fishing, tannin, honey, and they also acts as carbonsinks due to which NASA has referred to them as "the finest carbon scrubbers." (FSI, 2019)

Threats

Several species are listed as vulnerable or endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Clear cutting and trimming of trees for urban, agricultural, or industrial growth, hydrological changes, hazardous chemical spills, and eutrophication are some of the primary local threats to mangrove ecosystems across the world. Many of the people who live in nations with mangroves do so in the coastal area, where their activities frequently have a detrimental effect on the health of the mangrove forests. A further danger to mangroves and allied ecosystems like coral reefs is eutrophication, which is the process by which nutrients accumulate to greater than usual levels in a natural system. Sea level changes would affect mangrove structure and acreage, as well as patterns of flooding. Rainfall patterns may vary as a result of climate change, which would also affect local salinity regimes and the competitive relationships between mangroves and other wetland plants. Increased atmospheric carbon dioxide (CO), brought on by the combustion of fossil fuels and other reasons, is another aspect of climate change that may directly impact mangrove development. By promoting photosynthesis or enhancing water usage efficiency, elevated CO concentrations may promote mangrove growth, but it is uncertain what effects this growth enhancement will have on the environment (McKee, 2004)

An important hazard to the mangroves is anthropogenic activity. These delicate ecosystems are under danger owing to urbanisation, industrialization, and the concomitant discharge of home sewage, industrial effluents, and pesticide residues from agricultural fields. Mangroves are also harmed by aquaculture and Saltpan. 35,000 hectares of mangroves were devastated by shrimp cultivation alone. In just three decades, 40% of the west coast's mangroves have been transformed into farms and other types of communities.

Govt initiatives for conservation of mangrove ecosystem

Government has taken steps to protect sustain, conserve and augment forests in the country through promotional as well as regulatory measures. The promotional measures are being implemented through a Central Sector Scheme under National Coastal Mission Programme on ‘Conservation and Management of Mangroves and Coral Reefs’. Under this

programme, annual Management Action Plan (MAP) for conservation and management of mangroves are formulated and implemented in all the coastal States and Union Territories. Regulatory measures are implemented through Coastal Regulation Zone (CRZ) Notification (2019) under the Environment (Protection) Act, 1986; the Wild Life (Protection) Act, 1972; the Indian Forest Act, 1927; the Biological Diversity Act, 2002; and rules under these acts as amended from time to time. As per information provided by the World-Wide Fund for Nature, (WWF), India, the WWF India has enjoined citizens in nine states, which include Maharashtra, Goa, Gujarat, Andhra Pradesh, Tamil Nadu, Kerala, Odisha, West Bengal and Karnataka on mangrove conservation through the Magical Mangroves campaign. The Government under Centrally sponsored scheme for conservation & Management of Mangroves, extend assistance to Coastal State/UTs for implementation of action plans including survey and demarcation, alternation and supplementary livelihood, protection measures and education and awareness activities. The Ministry piloted an Integrated Coastal Zone management Project in Coastal stretches of 3 states namely Gujarat, Odisha and West Bengal, with objective of Conservation and Protection of Coastal resources which included plantation of mangroves as one of the major activities. In addition, State Government of Maharashtra has taken several proactive steps for conservation of Mangroves and a Mangrove Cell, dedicated for Mangrove conservation, has been establishment by the State Government. Further, Mangrove and Marine Biodiversity Conservation Foundation is also created for enhancing Mangrove cover and to promote research and livelihood activities under the Forest.Several strategies are being used by states to manage and conserve mangroves. Direct seed sowing, raised bed planting, and fishbone channel plantation are some significant methods used in Gujarat to restore damaged mangrove ecosystems. For cooperative project execution in mangrove regions, the Andhra Pradesh Forest Department has established Eco-Development Committees and Van Samrakshan Samithis. For sustainable mangrove protection, regular trainings are also held. Mangroves' ecology and biodiversity are being preserved in Maharashtra through conservation, restoration, regeneration, and maintenance. Under the Environment Ministry, the National Mangrove Committee was established in 1976. which concentrated on topics such as remote sensing-based mapping of mangroves, land surveys, etc., to estimate the pace of degradation, evaluating locations for creating reserve forests, conservation programmes, afforestation, R&D, etc.The Biotechnology Department launched a prototype bio-restoration initiative in the Sundarbans in 2013. It entails using natural grasses to stabilise damaged mangrove stretches (salt-tolerant varieties). The Bombay High Court has categorised mangroves as forests in 2005. The High Court ruled in 2018 that the destruction of mangroves violated residents' basic rights under Article 21 of the Constitution. The government has been working to preserve the mangroves ever since. More than 15,000 hectares of

mangroves were designated as reserve forest by the Maharashtra government in 2016. It is forbidden to build within 50 metres of these mangroves. Through the BOBLME (Bay of Bengal Large Marine Ecosystem) initiative, India and seven other nations from the Bay of Bengal region joined forces in 2018 to safeguard the mangroves. This initiative is being run by the UN Food and Agricultural Organization. A 15 million USD grant was approved by the GEF (Global Environment Facility) for this project.

MISHTI (Mangrove Initiative for shoreline habitats & tangible incomes)

A new initiative called MISHTI would make it easier to establish mangroves on salt pan areas and along India's coastline. The FM stated that the initiative will function through "convergence between MGNREGS, Campa Fund, and other sources." Following India's participation in the Mangrove Alliance for Climate, which was established during the 27th Conference of Parties (COP27) to the United Nations Framework Convention on Climate Change held in Egypt in November 2022, the MISHTI, or "Mangrove Initiative for Shoreline Habitats & Tangible Incomes," was established.

Mangrove cover

As reported to FRA 2020, 113 countries have areas of mangrove forest, totalling an estimated 14.79 million hectares. The largest area was reported in Asia (5.55 million hectares), followed by Africa (3.24 million hectares), North and Central America (2.57 million hectares) and South America (2.13 million hectares). Oceania reported the smallest area of mangroves (1.30 million hectares). More than 40 percent of the total area of mangroves was reported to be in just four countries: Indonesia (19 percent of the total), Brazil (9 percent), Nigeria (7 percent) and Mexico (6 percent) (FAO, 2020).

Since 1990, the area of mangroves has decreased by 1.04 million hectares, but the rate of change more than halved over the reporting period, 1990–2020 from 47 000 hectares per year in the period 1990–2000 to 21 000 hectares per year over the last ten years (FAO, 2020).

Mangrove cover of India

S.no	Year	Mangrove cover (Sq.km)	Change in Mangrove cover
1.	2011	4661.56	23.34 (w.r.t 2009)
2.	2013	4628	-34 (w.r.t 2011)
3.	2015	4740	112(w.r.t 2013)
4.	2017	4921	181 (w.r.t 2015)
5.	2019	4975.22	54.86 (w.r.t 2017)
6.	2021	4992.32	17.10 (w.r.t 2019)

(ISFR, 2011, 2013, 2015, 2017, 2019, 2021)

Mangrove cover of India (2021 Assessment)

The current assessment shows that Mangrove cover in the country is 4,992 sq km, which is 0.15% of the country's total geographical area. Very Dense Mangrove comprises 1,475 sq km (29.55 %) of the Mangrove cover; Moderately Dense Mangrove is 1,481 sq km (29.67 %) while Open Mangroves constitute an area of 2,036 sq km (40.78 %). There has been a net increase of 17 sq km in the mangrove

cover of the country as compared to 2019 assessment. The States that show significant gain in Mangrove cover are Odisha (8 sq km) and Maharashtra (4 sq km). The reason for the increase in Mangrove cover in Odisha is mainly due to the natural regeneration, plantation activities in suitable land like on the banks of the rivers near the estuary and on intertidal mud-flats associated with the areas that are inundated by sea water on a daily cycle. The increase in Mangrove cover has been observed in the districts of Kendrapara, Jagatsinghpur and Balasore in Odisha. In Maharashtra, the increase in Mangrove cover is mainly due to natural regeneration. The increase has also been observed in the South 24 Parganas district of West Bengal.

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The role of seed banks in plant conservation

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Abstract

Seed banks are important tools for plant conservation. They can help to protect plants from extinction by storing their seeds in a safe place. Seed banks can also be used to restore plants to areas where they have been lost. There are two main types of seed banks: In situ and Ex situ. Despite the difficulties, seed banks are a crucial tool for protecting plant species. Seed banks are a valuable tool for plant conservation. They can help to ensure that plants continue to thrive, even in the face of threats such as climate change and habitat loss. Seed banks are an important part of the global effort to conserve plant diversity. They play a vital role in protecting plants from extinction and in restoring plants to areas where they have been lost. They are essential in maintaining plant genetic variety and making sure that they are accessible to future generations.

Keywords: seed bank, ex situ and in situ seed banks, conservation, plant diversity

Introduction

Plant species' ability to produce seeds that remain viable in the soil enables them to bridge habitat conditions that are temporally unfavorable for germination and establishment, spreading germination risk across a longer period of time and long-term preservation of population genetic diversity. The seed bank influences the course of secondary succession at the community level following major or minor disturbances. Seeds produced by the vegetation and seeds disseminated from other areas replenish the seed bank, and germination from the seed bank results in seedling recruitment in the vegetation. Additionally, even after a species vanishes from the vegetation on the site, its seeds may still be found in the soil. The seed bank was viewed as a valuable prospective seed source for the regeneration of plant communities because of these factors (Bossuyt and Honnay, 2008).

The predicted climatic changes will unavoidably have an impact on seed ecology because of the strong mechanistic link between climate factors and seed dormancy and germination. As a result, there will be an effect on seed banks, which are crucial for maintaining population persistence, especially in environments prone to stochastic or changing disturbance regimes (Ooi, 2012.). It is possible to postpone germination from a seed bank so that seedling emergence occurs when conditions are ideal for seedling establishment and recruitment is most important for re-establishing populations. As a result, seed bank persistence is essential, and the seed bank's principal function is to maintain viable seeds in between recruiting sessions. During this time, the seed bank may experience net losses as a result of either declining seed

viability or germination and seedling emergence under unfavorable environmental circumstances.

At the ambient relative humidity, drying seeds cease to metabolize and become effectively quiescent, or cryptobiotic (Walters and Pence, 2021). However, shelf life is not limitless. Quiescent organisms gradually lose their ability to recuperate, and in the case of seeds, even when the necessary conditions are present, they are unable to germinate. In other words, the sample's usefulness is constrained by the lifespan it has attained through storage. This survival time, or lifespan, is dependent on the temperature and relative humidity (RH) of the storage environment.

There are two main types of seed banks: in situ and ex situ. In situ seed banks store seeds in the wild, where they can continue to grow and evolve. Ex situ seed banks store seeds in a controlled environment, such as a laboratory or a greenhouse. In situ seed banks are often used to protect plants that are threatened or endangered. They can help to ensure that these plants have a safe place to grow and reproduce. In situ seed banks can also be used to study plants and to learn more about their ecology. Ex situ seed banks are often used to store seeds of plants that are rare or that are not found in the wild. They can also be used to store seeds of plants that are threatened by climate change or other environmental factors. Ex situ seed banks can help to ensure that these plants do not go extinct. Ex situ seed conservation is projected to cost as little as 1% of in situ conservation as a safeguard against extinction (Li and Pritchard, 2009). Ex situ plant conservation assumptions, costs, hazards, and scientific difficulties vary by species, method used, and intended storage time.

Seed collection and preservation

One of the primary functions of seed banks is to collect and store seeds from a wide range of plant species. These seeds are meticulously collected, ensuring genetic diversity is represented. Through partnerships with botanic gardens, research institutes, and conservation organizations, seed banks acquire seeds from diverse ecosystems, including endangered and rare species. The collected seeds undergo careful processing, cleaning, and drying to ensure their long-term viability. They are then stored under controlled conditions of temperature and humidity to maintain their viability for extended periods, ranging from decades to centuries.

(Source: Navdanya Community Seed Banks, India)

Genetic diversity preservation

Seed banks serve as repositories of genetic diversity, collecting, storing, and conserving seeds from a wide range of plant species. By storing seeds from diverse populations, both wild and cultivated, seed banks ensure the preservation of genetic variation. This genetic reservoir is crucial for future plant breeding programs, restoration initiatives, and adaptation to changing environmental conditions.

Conserving endangered species

Seed banks serve as repositories of genetic material for endangered plant species. Many plants face the threat of extinction due to habitat loss, climate change, and other human activities. Seed banks provide a safe haven for these species, ensuring their genetic diversity is preserved. By storing seeds from endangered plants, seed banks act as insurance against their potential extinction. If the natural populations decline or become extinct, the seeds can be used for future conservation efforts, such as habitat restoration, reintroduction programs, or scientific research.

Supporting ecological restoration

Seed banks play a crucial role in ecological restoration projects. When habitats are degraded or destroyed, restoring them with native plant species becomes essential for ecosystem recovery. Seed banks supply the necessary seeds for such restoration efforts. By preserving a wide range of plant species, seed banks contribute to the availability of diverse and locally adapted seeds, which are essential for successful restoration projects. These seeds not only aid in re-establishing vegetation but also help in the recovery of associated wildlife and ecosystem functions.

Research and education

Seed banks support scientific research and education by providing plant materials for studies, experiments, and educational programs. Researchers can access the seeds and associated data from seed banks to study plant biology, genetics, and ecology. These resources aid in understanding plant adaptations, developing conservation strategies, and addressing pressing ecological challenges. Additionally, seed banks collaborate with educational institutions to raise awareness about plant conservation and promote the importance of biodiversity.

Gene Bank (seed storage)

(Source: International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India)

Seed banks play an important role in plant conservation. They can help to protect plants from extinction, to restore plants to areas where they have been lost, and to study plants and learn more about their ecology. Here are some of the specific benefits of seed banks:

- They can help to protect plants from extinction by storing their seeds in a safe place.
- They can be used to restore plants to areas where they have been lost.
- They can be used to study plants and learn more about their ecology.
- They can help to develop new crops and varieties of plants.
- They can help to protect plant genetic diversity.

Here are some of the challenges of seed banks:

- They can be expensive to operate.
- They can be difficult to maintain.
- They can be vulnerable to disasters.

- They can be difficult to access for some people.

Challenges and future prospects

Despite their significant contributions, seed banks face several challenges. Some of these include the high costs of collection, processing, and storage, as well as the need for continuous monitoring and renewal of seed stocks. Additionally, ensuring the representativeness of stored seeds from diverse habitats and addressing ethical considerations related to access and benefit-sharing are ongoing challenges.

Looking to the future, advancements in seed banking techniques, such as cryopreservation and tissue culture, offer exciting possibilities. These methods allow for the long-term storage of plant embryos, tissues, and cells, further expanding the scope of genetic preservation. Moreover, enhancing collaboration between seed banks and conservation practitioners can improve the effectiveness of conservation strategies.

Conclusion

Seed banks play an indispensable role in plant conservation, acting as repositories of genetic diversity, guardians of endangered species, and facilitators of ecological restoration. They provide scientists, researchers, and conservationists with the means to preserve, study, and propagate plant species, enabling sustainable land management and biodiversity conservation efforts. As we face mounting environmental challenges, seed banks stand as crucial pillars in our collective mission to protect and restore the diversity and resilience of our planet's plant life. Investing in and supporting seed banks are essential to ensure a greener and more sustainable future for generations to come.

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शहतूत (मोरस अल्बा) की खेती के तरीके

रोहित, भालेंद्र सिंह राजपूत एवं अंकितपाल
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परिचय एवं वितरण

शहतूत (मोरस अल्बा) एक तेजी से बढ़नेवाला लकड़ी का पौधा हैं। जिसकी जड़ें गहरी होती हैं और यह मोरेसी परिवार से संबंधित है । यह आसानी से फैलता है और उपजाऊ मिट्टी में सख्ती से बढ़ता है । यह मूल रूप से एशिया के समशीतोष्ण क्षेत्र से आया था और अब पूरी दुनिया में फैल गया है और हमारे उष्णकटिबंधीय जलवायु में खुद को अच्छी तरह से ढाल रहा है। शहतूत का उपयोग इसके फल के लिए, एक स्वादिष्ट सब्जी के रूप में, औषधीय प्रयोजनों के लिए, भू निर्माण के लिए और पत्तियों और तनों का उपयोग पशुओं के चारे के रूप में किया जाता है । शहतूत, अपने युवा झाड़ी चरण में, जुगाली करनेवाले जानवरों जैसे भेड़ और बकरियों और मोनोगैस्ट्रिक जैसे सूअरों के लिए उत्कृष्ट चारा है। पत्ते और तने जानवरों के लिए स्वादिष्ट और बहुत सुपाच्य होते हैं।

फेनोलॉजी

यदि शहतूत के पेड़ को बीज से उगाया जाता है, तो इसके फूल आने में लगभग 5-10 साल लगते हैं, लेकिन एक कलम लगाए हुए शहतूत में फूल आना और फल देना शुरू हो जाएगा या दूसरे साल । सामान्यत: पत्ती गिरना - नवम्बर – दिसम्बर, पत्तियों का नवीनीकरण - मार्च – अप्रैल, पुष्पन – मार्च-अप्रैल, फल पकने - अप्रैल-जून, फलों का स्वाद स्वादिष्ट होता है और ये सफेद या लाल रंग के हो सकते हैं। पेड़ लगभग पांच साल की उम्र में व्यवहार्य बीज पैदा करना शुरू करते हैं।.

जलवायु

एम.अल्बा उपोष्णकटिबंधीय या हल्के तापमान जलवायु वाले क्षेत्रों में बढ़ता है। जबकि जनवरी में न्यूनतम तापमान कुछ दिनों के लिए हिमांक से नीचे जा सकता है, अधिकतम छाया तापमान शायद ही कभी 43^{0}C से ऊपर जाता है। इसकी खेती के कुछ स्थानों में अधिकतम छाया तापमान 48^{0}C तक भी पहुँच सकता है । अधिकतम विकास के लिए पर्याप्त पानी की आपूर्ति आवश्यक है, विशेष रूप से बढ़ते मौसम के दौरान। वार्षिक वर्षा लगभग 400 मिमी से 4500 मिमी के बीच होती है और इसका अधिकांश भाग मानसून के मौसम में प्राप्त होता है। लगभग 1200 मिमी वार्षिक वर्षा वाले क्षेत्रों में इसकी अच्छी वृद्धि के लिए सिंचाई आवश्यक है।

मिट्टी

एम.अल्बा कई तरह की मिट्टी में उग सकता है, रेतीली दोमट से लेकर दोमट मिट्टी तक, हालांकि यह जलोढ़, गहरी, दोमट मिट्टी में पर्याप्त नमी की उपलब्धता के साथ सबसे अच्छी होती है। पेड़

क्षारीयता को सहन नहीं कर सकता है और 6.0 और 7.5 के बीच पीएच के साथ मिट्टी पर सबसे अच्छा बढ़ता है । पहाड़ियों में नमी की उपलब्धता विकास को बाधित करती है, और शुष्क ढलानों पर पेड़ों का बढ़ना जारी रहता है।

सिल्वीकल्चरल विशेषताएं

एम.अल्बा एक छाया-उत्पादक वृक्ष है जो धूप की आवश्यकता वाली अन्य प्रकार की वनस्पतियों के नीचे खेती करने से लाभान्वित होता है । यह बहुत अच्छी तरह से काटता है और पोलार्ड (Pollarding) करता है । 30 सेंटीमीटर व्यास से बड़े पेड़ों की कोपिंग (Coppicing) क्षमता आमतौर पर खराब होती है। यह हल्की पाला सहन कर सकता है । इसकी पानी की आवश्यकता अधिक होती है । यह सूखे का अनुभव करता है, जैसा कि भविष्यवाणी की जा सकती है कि यह एक सतह फीडर है । यह ब्राउज़िंग (Browsing) और आग के लिए असुरक्षित है ।

प्राकृतिक प्रजनन

एम.अल्बा कोपिंग या बीज द्वारा प्रजनन करता है । पक्षी या पानी बीज फैलाव के दो मुख्य साधन हैं । सही जगह पर बोने पर ऐसे बीज जल्दी अंकुरित (Germinated) हो जाते हैं । बीज को अंकुरित होने के लिए गीली, अच्छी जल निकासी वाली मिट्टी की आवश्यकता होती है । भारी छाया हानिकारक होती है, जबकि हल्की छाया बीज अंकुरण और अंकुर स्थापना के लिए आदर्श होती है । हल्के रंग के मुकुटवाले पेड़ पौधों के नीचे उगने के लिए एक छतरी प्रदान कर सकते हैं।

अंकुर स्थापना के लिए अनुकूल माने जानेवाले कारक

पर्याप्त छाया, लम्बे और घने खरपतवारों से रहित, मिट्टी में पर्याप्त नमी, मिट्टी लवणता से मुक्त होनी चाहिए, जानवरों को ब्राउज़ करने से सुरक्षा, एम.अल्बा में सिंचित वृक्षारोपण के क्षेत्रों में आक्रामकता की प्रवृत्ति है, पेड़ अच्छी तरह से कॉपपाइस करता है और कॉपपीस के माध्यम से पुनर्जीवित किया जा सकता है ।

कृत्रिम प्रसार

एम.अल्बा का गुणन करने के लिए जड़वाली शाखाओं की कटिंग और नर्सरी में उगाई गई पौध दोनों का उपयोग किया जा सकता है । जिन पौधों को नर्सरी में पाला गया है उन्हें या तो पूरे पौधे के रूप में या स्टंप (stump) के रूप में बाहर रखा जाता है, बादवाले पहले की तुलना में अधिक परिणाम देते हैं । सीधी बिजाई शायद ही कभी फलदायी परिणाम देती है ।

बीज संग्रह और भंडारण

पके फलों को पेड़ों से एकत्र करना चाहिए, फलों को कभी भी जमीन से नहीं तोड़ना चाहिए क्योंकि ऐसे फलों के बीजों पर आमतौर पर कीड़ों का आक्रमण होता है, रस निकालने के लिए फलों को कपड़े में दबाया जा सकता है, और लुगदी को फिर धूप में सुखाया जाता है, हाथ से रगड़ा जाता है, और बीज निकालने के लिए फटक दिया जाता है । लगभग 430-460 बीजों का वजन एक ग्राम होता है । फलों को छाया में ढेर किया जाता है, रगड़ा जाता है, और बीज को अलग करने के लिए पानी में धोया जाता है, जिसे भंडारण से पहले कुछ दिनों के लिए धूप में सुखाया जाता है । कहा

जाता है कि भंडारण के एक वर्ष के बाद बोरियों में रखे बीजों की व्यवहार्यता पूरी तरह खत्म हो जाती है। बीज दो साल से अधिक समय तक रह सकता है जब इसे बारीक, सूखी रेत या राख की परतों में रखा जाता है। बीज बारीक सूखी रेत या राख की परतों में स्तरित होकर दो साल से अधिक समय तक ठीक रहता है।

नर्सरी तकनीक

नर्सरी में बुवाई मई-जून में बीज एकत्र करने के तुरंत बाद की जाती है। बुवाई की पंक्तियों को लगभग 20 सेमी अलग रखा जाता है । यह सुझाव दिया गया है कि लगभग 30 से 90 दिनों के लिए लगभग 50^{0}C के तापमान पर नम रेत में स्तरीकरण अंकुरण को बढ़ा सकता है। यह भी सुझाव दिया गया है कि बीज को लगभग एक सप्ताह तक ठंडे पानी में भिगोने से तेजी आएगी और एकसमान अंकुरण सुनिश्चित होगा । बीज को चींटियों द्वारा दूर ले जाने से बचाने के लिए मिट्टी के तेल के साथ बीज का पूर्व-उपचार करने की भी सिफारिश की जाती है। मिट्टी के तेल की एक बोतल लगभग 37 किलो बीज को उपचारित करने के लिए पर्याप्त होती है, एक समान बुवाई सुनिश्चित करने के लिए बीज को राख या चूरा के साथ मिलाया जाता है।

एम.अल्बा की क्लोनल नर्सरी

एक समान बुवाई सुनिश्चित करने के लिए बीज को राख या चूरा के साथ मिलाया जाता है। यह धीरे-धीरे महीन गंदगी से ढक जाता है, और एक या दो सप्ताह के बाद, अंकुरण शुरू और समाप्त हो सकता है। पौधों को लगभग 60 x 60 सेमी की दूरी पर तब लगाया जाता है जब वे लगभग 10 सेमी लंबे होते हैं । प्रत्यारोपण (transplant) सर्दियों में किया जा सकता है। उनके विकास की गति के आधार पर, पौधों को ठूंठ पैदा करने के लिए एक या दो साल के लिए नर्सरी में रखा जा सकता है । स्टंप के लिए आदर्श कॉलर व्यास लगभग 2 सेमी माना जाता है।

रोपण तकनीक

व्यापक रूप से इस्तेमाल की जानेवाली दो तकनीकों में से, स्टंप से रोपण और पूरे पौधे को लगाना, बादवाला अधिक सफलता प्रदान करता है और इसकी अनुशंसा की जाती है। स्टंप बनाने के लिए एक या दो साल पुराने अंकुरों का उपयोग किया जाता है, और आमतौर पर यह आवश्यक होता है कि कॉलर का व्यास कम से कम एक सेंटीमीटर हो । 1.5 से 2 सेमी के कॉलर व्यासवाले स्टंप अच्छी तरह से काम करते हैं। तैयारी के दौरान तनों को गिरने से रोकने के लिए, लगभग 22 सेमी के जड़ व्यास और 8 सेमी के अंकुर के साथ स्टंप बनाया जाता है । उन्हें चारों ओर लपेटे हुए नम बोरे के साथ ले जाया जाता है। रोपण 30 सें.मी. 3 गड्ढों या क्रोबार छिद्रों में किया जा सकता है। एम.अल्बा उगाने के लिए शाखाओं की कटिंग भी लगाई जा सकती है। फिर भी, इस तकनीक का उपयोग अच्छी किस्म के क्लोनल सामग्री की मात्रा बढ़ाने के लिए किया जाता है, न कि बढ़ते वृक्षारोपण के लिए । दूरी पौधों को उगाने के लक्ष्यों द्वारा निर्धारित की जाती है। अगर पत्तों के उत्पादन के लिए पेड़ों को परागित किया जाना है, तो नज़दीकी दूरी पर्याप्त हो सकती है । यदि पत्ती और इमारती लकड़ी के उत्पादन को संयुक्त करना है, तो 4 × 4 मीटर या 5 x 5 मीटर की व्यापक दूरी की आवश्यकता हो सकती है।

एम. अल्बा की क्लोनल नर्सरी

एम.अल्बा का परिपक्व वृक्ष

एम.अल्बा का फल

आर्थिक महत्व

भोजन

विटामिन बी 12 के अपवाद के साथ, पत्तियां अविश्वसनीय रूप से पोषक तत्वों से भरपूर होती हैं और इसमें विटामिन बी कॉम्प्लेक्स, सी (200-

300 मिलीग्राम/100 ग्राम), डी और विटामिन शामिल होते हैं।

फ्लेवनॉल्स

फलों का ताजा सेवन किया जाता है, या इसे जूस और स्टॉज में पकाया जाता है, और उन्हें कभी-कभी सब्जियों के रूप में खाया जाता है।

चारा

डेयरी गायों को बेहतर दूध देने के लिए, चारे के रूप में उन्हें प्रतिदिन 6 किलो तक पत्ते दिए जा सकते हैं।

उपज

छाया में सुखाई गई पत्तियों को चारे में मिलाने से पक्षियों के स्वास्थ्य और अंडे के उत्पादन में सुधार होता है।

ईंधन

4370–4770 किलो कैलोरी/किग्रा के कैलोरीमान के साथ औसत ग्रेड की लकड़ी का उत्पादन करता है।

फाइबर

छाल को पेपर पल्प में संसाधित किया जाता है, और फाइबर कपड़ा क्षेत्र के लिए उपयोगी होता है। लकड़ी सफेद लेखन और मुद्रण कागज के लिए पर्याप्त शक्ति के साथ सल्फेट लुगदी का उत्पादन करती है।

इमारती लकड़ी

670-850 किग्रा/घन मीटर के घनत्व के साथ एक मध्यम वजन की दृढ़ लकड़ी एम.अल्बा द्वारा उत्पादित की जाती है। हर्टवुड सफेद से हल्के पीले रंग का, 4 सेंटीमीटर तक की बारीक परिभाषित सीमाओं के साथ, जोखिम के साथ सुनहरे या लाल-भूरे रंग में बदल जाता है।

सैपवुड

सीधे अनाज, अपेक्षाकृत मोटे और समान बनावट, और अंगूठी झरझरा सामग्री में असमान बनावट सामग्री, एक बार चमकने के बाद, लकड़ी में चांदी का दाना अंततः उम्र के साथ फीका पड़ जाता है। लकड़ी में सीज़निंग के दौरान विकृत होने की प्रवृत्ति होती है। यह अच्छी तरह से मौसम करता है और देखने, काम करने, मोड़ने, मोड़ने और खत्म करने में आसान है। इसका उपयोग घरों, नावों, बीम, पदों, फर्श, पुलों, कृषि उपकरणों, अलमारियाँ, फर्नीचर और टर्नरी, विशेष रूप से पिकर आर्म्स, बॉबिन और टूल हैंडल के निर्माण के लिए किया जा सकता है; इसे गाड़ी और गाड़ी के प्रवक्ता, डंडे और शाफ्ट बनाने के लिए भी मोड़ा जा सकता है। यह क्रिकेट के बल्ले, टेनिस और बैडमिंटन रैकेट और हॉकी स्टिक जैसे खेल के सामान के लिए भी अत्यधिक बेशकीमती है।

शराब

फलों के रस को किण्वित कर के शराब बनाई जा सकती है।

टैनिन या रंजक

इसमें 32% टैनिन होता है, जो इसे टैनिंग और रंगाई के लिए अच्छा बनाता है।

तेल

फलों के प्रमुख आवश्यक तेल घटक सिनेओल, गेरानियोल, लिनालिल एसीटेट, अल्फा-पिनीन और लिमोन हैं।

औषधि

फलों का उपयोग गले में खराश, अपच और उदासी के इलाज के लिए किया जाता है; छाल, पत्तियों और युवा शाखाओं का उपयोग गंभीर सर्दी, खांसी, लाल आंखें, कीड़े के काटने और

घावों के इलाज के लिए किया जाता है। छाल पेट की परेशानी, स्नायु संबंधी लक्षणों और जलोदर के इलाज के लिए भी सहायक है।

अन्य उत्पाद

इसकी खेती सेरीकल्चर व्यवसाय के लिए आवश्यक है और इसकी पत्तियों के लिए इसे व्यापक रूप से उगाया जाता है, जिसका उपयोग रेशम के कीड़ों के प्रजनन में किया जाता है।

कीट और रोग

एस्कोटिस सेलेनारिया, कैकोसिया माइकेसेना, डायक्रिसिया इंडिका, डी. ओब्लिकुआ, मेटानस्ट्रिया हिरटाका के लार्वा पेड़ को ख़राब करते हैं; डाइकोक्रोसिस पंक्टिफेरालिस के लार्वा फल को नुकसान पहुंचाते हैं; मिली बग पौधे पर प्रजनन करते हैं । साही युवा को भी हानि पहुँचाते हैं पौधे।

कई कवक रोग पौधे पर हमला करते हैं: दिल की सड़न, स्पंजी सड़न, पत्ती की जगह, तना सड़न, ख़स्ता फफूंदी, जंग और तना नासूर।

Tree root system architecture studies: Relevance in forestry and agroforestry

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Root system architecture (RSA) is an important plant trait that determines its survival and growth of any species in particular environment. It is complex of genotype and environmental condition and is crucial for anchoring the plant to the soil, sustaining vital functions of plant, maintaining its productivity and storing food. Understanding the root system architecture is crucial to deploy architecture as well as various root features of trees to enhance yield of all component in agroforestry, to reclaim particular problematic soil and to develop desired root ideotypes for particular land use system. Although crucial for survival water as well as nutrient acquisition and ensuring competitive fitness of trees not much attention has been given to explore RSA because being underground thus it has been called as hidden half by many scientists. In trees very few studies has been carried to study RSA. This paper summarizes the importance of tree RSA and its relevance in forestry and agro-forestry.

Key words: Tree, Root system Architecture, importance of RSA, agroforestry

Introduction

Roots are the underground organ of the plants that anchors plants to the ground and absorbs water and mineral salts from soil. In most of the trees, radicle root elongates to from primary root (tap root), primary roots then bear lateral roots of several orders which are referred to as secondary roots, tertiary roots, quaternary roots etc. The main functions of the root system is absorption of water and minerals from the soil, providing a proper anchorage to the plant and storage of food material, production of plant growth regulators and establishment of the biotic and abiotic interaction at rhizosphere.

The term root system architecture (RSA) is described as a spatial configuration of a root system that includes description of primary roots, lateral roots (Fitter, 1991; Lynch, 1995). The architecture of a root system is described with various variables like branching frequency of the nodes, length of internodes, branching angle, the mortality of apices and axes, and root topology (Deo, 1974; Fitter, 1991), studies on root depth in soil, root spread, root orders and root angles etc. Root architecture, growth and development are poorly understood but the basic structure of the root is almost same in all the plant species. RSA is result of genetic

constitution of plant, specific physio-logical traits, acting in coordination or independently hence controlling the orientation, elongation, branching, and persistence of individual roots (Lynch, 2005) indicating that RSA is dynamic as well as environmentally plastic. RSA is are important for survival of plants but because of difficulty of studying them not much research has been carried out on roots architecture and other features especially in trees where it is very difficult to excavate the massive root system. Therefore roots have been described as hidden half (Waisel et al., 2005).

Tree roots can constitute >60 % of total biomass in forest ecosystems and helps in providing mechanical strength to trees besides carrying out water and nutrient supply function. Trees root architecture studies give detail overview of entire root structure, distribution. RSA and extent spatial distribution of coarse roots determines ability of a plant to exploit unevenly distributed soil resources and finer root role remains limited (Lynch, 1995). RSA has been proved to be a critical factor responsible for the plant survival, water and nutrient acquisition efficiency and competitive fitness in a given environment (Grime et al., 1986).

Tree root architecture studies are important in establishment of resource efficient Agroforestry system as roots needed to be manipulated so that there is minimum competition between trees and other crop or grass components. Trees with deep roots facilitate growth of grasses and crops under agro-forestry and shallow root presence give an advantage as they can be trimmer easily to lessen up the competition with crops. Based upon root architecture studies we can choose trees for agroforestry system to reduce competition between crops and trees and enhance productivity. Further impact of pruning and other above ground tree management practices can be studied on root system. Knowledge of the extent and distribution of tree root systems is essential for managing trees in the built environment/agroforestry systems. Further these studies provide information on impact of soil types, nutrient status, water table on root growth and development.

Problematic sites reclamation by trees also depends on type of root architecture, e.g. wetlands reclamation requires trees with shallow and extensive roots whereas sites with high soil erosion requires trees with deep and extensive roots so that large volume of soil can be conserved. Knowledge of root structure also give insight into the amount of carbon captured in the below ground part of trees. To evaluate below-ground ecosystem services, a reliable characterization of the spatial distribution of root density is fundamental. Better predictions of C sequestration in plantations require calculating both above- and below-ground biomass accurately, for a wide range of species and conditions. Accurate characterization of total tree biomass is critical for robust estimates of C storage. Root excavation work and mapping of the root system also provide an opportunity to enhance hydrological models that aim to understand the flow of water in forested systems. Rooting depth, distance, and volumes are critical but missing links to predicting water update by trees.

Studying provenance level variation in root architecture will help in unraveling

the extent of genetic and environmental variation in root architecture and will help in breeding trees with desired roots and developing desired root phenotypes in trees. Therefore Understanding the development and architecture of roots thus holds potential for the exploitation and manipulation of root characteristics to both increase tree yield and optimize agricultural land use.

Methods to study root system architecture of trees grown under agroforetsry:

Various destructive and non destructive methods are applied in studying RSA in trees.

Excavation

Excavation is destructive method which includes manual digging of trenches and up-rooting using pick exe, trowel, sometimes explosives and high pressure water or air. Excavation is done from tree stem base and is extended outwards; excavations is done during the dormant season and the area around the tree is watered thoroughly prior to excavation to soften the ground and make it possible to excavate without damaging the tree roots and also to expose roots greater than 1mm in diameter intact. Excavations give full biomass per individual and also allow taking photographs/3D-scans of whole (coarse) root systems providing valuable data on the vertical and horizontal root system distribution.

Coring

Coring is also a destructive method that includes manual pushing or hammering of cylindrical sampling equipment into the soil using various devices viz. simple or sharpened steel augers and advanced cryogenic devices or vehicle-mounted or hand-held mechanical devices for coring to greater depth.

Ground Penetrating Radar (GPR)

GPR scans the root systems of large trees under field conditions and is non-invasive and is environmentally safe. Its accuracy is sufficient to resolve structural roots with diameters ranging from 1 cm to 3 cm or high. It can characterize roots both at the individual tree level and stand levels thereby correlations between tree-and stand-level process can be established.

X-ray computed tomography

It is a non-destructive imaging technique that can visualize the internal structure of opaque objects as μCT scanners takes projections of roots from different angles, measuring the attenuation of ionizing radiation passing through the roots. These projections are combined to reconstruct a three-dimensional data set.

Factors affecting root growth, root distribution patterns and Root system architecture

Patterns of root distribution observed at the species level can be described as either deep/shallow, narrow /wide or vertical/horizontal but actual root distribution pattern is result of both genetic and environmental interactions and it differs between species, site conditions, and developmental stage (Kalliokoski et al., 2008). RSA is very complex which is attributed to genotype, species of the plant, soil composition and of water and nutrients availability. The direction of root growth is determined by various tropisms i.e. phototropism, gravitropism, hydrotropism (Malamy, 2005).

RSA is impacted by inherent/genetic factors like alteration in cell division at primary root meristem, capacity to form

and spread lateral root etc. Besides this external factors like nutrient availability, plant growth hormones, water availability and soil density salinity have major impact on root architecture High nitrate concentration in soil decreases lateral growth of roots, whereas high phosphate content enhances the lateral root growth, sulphate is limiting in soil the root system become branched. Presence of phosphorus in upper layer of soil enhances lateral root expansion and decrease in primary root elongation.

Plant growth hormones also impact RSA as it has been reported that increase in ABA concentration increases primary root length, IAA is required for lateral root formation and increase in cytokinin reduces the lateral root formation.

Soil consisting of high solid part than water and air space poses mechanical impedance to the roots and leads to the decrease in primary root elongation and increase in root diameter. Lateral root expansion is not impacted by this condition but they remain shallow. Soil salinity also influences the root architecture as it enhances lateral root expansion but decreases primary root elongation. Water logging or excess of irrigation lead to restriction of root growth and low water such as drought leads to the increase in primary root length.

Root architecture studies in trees and agro-forestry

Tree root architecture has been less extensively studied in comparison to other plant species. Root architecture in tree is a resultant of genotype of tree, species, age, and external factors like topography, nutrients availability, climate and type of soil. Genotype of tree coupled with the external factors impact type of roots produced, maximum outward growing distance of roots from stem, maximum growing depth and deformation of the root system. In forest tree species not much extensive RSA studies have been carried out and this is the reason why roots are called hidden half.

Tree being perennial consists comprises of woody perennial as well as non woody seasonal roots and this type of root system guarantee anchorage, absorptive potential and gives the capacity to increase root length at selected periods during the season when the need to explore more areas for water and nutrients becomes necessary. The new roots produced during any season are of two types highly extended roots of unlimited growth potential with large diameter and short seasonal roots with limited growth potential and smaller diameter (Joseph, 1998). Later some of the seasonal extended roots survive and develop secondary woody tissues forming part of permanent root system whereas short roots are seasonal with a short life span which varies depending on species and environmental conditions (Joseph, 1998).The structural root system of trees is laid down when trees are juvenile and nutrient and water supply, directional primary growth and secondary thickening in roots are influenced by external mechanical loading, e.g. dynamic wind loading or substrate movement (Coutts, 1983; Telewski, 2006; Perez, 2012). Only in few species *Pinus pinaster*, *Robinia pseudoacacia*, *Eucalyptus camaldulensis*, *Quercus douglasii*, *Stipa pulchra*, *Picea sitchensis*, *Larix decidua*, *Melia volkensii*, *Quercus pubescens Bauhinia purpurea*,

Grewia optiva, *Eucalyptus tereticornis* and *Leuceana leucocephala* etc. RSA has been studied.

Knowledge about tree crop interactions is very important in Agroforestry systems especially below ground but very few studies have been carried out focusing on tree root system architecture in agroforestry. However, very few work has been carried out to study RSA of trees under agro-forestry and only few studies on impact of canopy pruning of trees under agro-forestry has been studied. Canopy pruning has been reported to decrease tree root length density and specific root length thereby reducing the below ground root competition. This has been reported to increase crop grain yield and ultimately reduce negative tree crop interaction for below ground and above ground resources under agro-forestry systems.

Conclusion

Knowledge of tree root system architecture is therefore crucial for successful establishment and management of any agroforestry system for optimum production by avoiding any kind of negative below ground interaction between various crop components. Besides this reclamation of particular problematic soil/lands requires a desired tree root ideotype and knowledge of RSA of tree species can facilitate use of proper tree species having desired root ideotype on such problematic soil. Further based on tree RSA breeding strategies can be developed to breed trees with desired root architectural ideotypes for optimization of yield in agroforestry system by reducing negative interaction.

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Genetic diversity in *Balanites Aegyptiaca* (Soapberry Tree) – A prospective tree to augment wide array of economic and ecosystem services in major Indian ravines

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Introduction

Balanites aegyptica (Syn. *Ximenia agyptica*) belongs to family Balanitaceae. It is popularly known as Desert date or soapberry tree or torchwood tree. It is indigenous to Sahel, dry lands of Africa, Asia and Arabian Peninsula. This species is widely naturalized in many parts of the world. It has wide ecological distribution, but is mainly found on alluvial site with deep sandy loam. After the seedling stage, it is heavy light demanding species and prefers open woodland and savannah for natural regeneration. This is one of the most common trees in Senegal. It is also found India, Iran and Pakistan (Amalraj and Shankarnarayan, 1986). The species is distributed at altitudes of between 450 to 600 m above sea level with a rainfall between 200 and 500 mm per annum. *B. aegyptiaca* had been used over thousands of years in the among the arid zone regions of world (Von Maydell, 1986). It is belonging to the *Zygophyllaceae* or *Balanitaceae*. It can be found in many kinds of habitat, tolerating a wide variety of soil types, from arid to sub humid. It is relatively tolerant of drought, flooding, livestock activity, and wildfire. It has wide ecological distribution; well grown on low-lying, level alluvial sites with deep sandy loam and uninterrupted access to water such as valley floors, riverbanks or the foot of rocky slopes. This tree having multi branches, spiny shrub or tree grows upto height of 10 m tall. Crown is spherical and main trunk is short often branching starts near the base. Bark dark brown, deeply fissured. Branches armed with stout yellow or greenish thorns up to 8 cm long. Leaves with two separate leaflets; leaflets obovate, asymmetric, 2.5-6 cm long, bright green, leathery with fine hairs when young. Flowers are small fascicles present in the leaf axils, yellowish-green hermaphroditic and pollinated by insects. The species has, especially in the equatorial zone, a pronounced diffuse flowering and fruiting habit; flowers and fruits occur during a prolonged season although a peak is always encountered. Fruit maturation occurs before rainy season where pronounced seasonal climate is common. Fruit are long narrow to round drupe, 2.5 - 7 cm long, and 1.5 – 4.0 cm in diameter. Young fruits green and tormentose, turning yellow and glabrous when matured. Fruit pulp is edible and bitter-sweet in taste. Seeds are pyrene (stone) form, 1.5-3 cm long; light brown, fibrous and extremely hard. It makes up 50-60 % of the fruit. There are 500 -1500 clean seeds per kg. The fleshy pulp of the fruit is eaten fresh or dried. This fruit contains 64 -72% carbohydrates, plus crude protein,

steroidal saponins, vitamin C, ethanol and other minerals (Abu Al-Futuh, 1983). All parts of the tree have a medicinal uses including fruits, nuts, barks and roots. The leaves and fruits eaten by goats, sheep and camels; thorny branches used for live-fencing. It is widely used as good firewood and charcoal; edible fruit and nuts have 30-40 % of edible oil (Dubey *et al.,* 2011). Both fruits and kernel were widely used livestock feed in many countries during the dry season and drought periods in the dry tropical region. In addition to that one tree can produce up to 100 - 150 kg of fruits per year (Schimdt, and Joker, 2000), and the kernel represents 15% of fruit (Elfeel and Warrag, 2006). Fruits and sprouts are all eaten by livestock. *Balanites aegyptica* is mainly propagated by seeds; it is used primary propagated material in natural as well as artificial regeneration for raising seedling stock. This is major factor responsible for huge variation in the natural stands. This dry fruits contributed 38 % of the dry matter intake of goats and other wild animals during dry seasons in the arid and semi arid regions. The wood is hard, durable and easy to work, but the small stem size and the tendency to fluting make sawmill processing difficult. Wood is highly suitable for wood carving and handicraft making.

Vegetation is one of the major limiting factors on ravenous lands. The potential of trees in reclamation of land is largely governed by canopy cover, ground vegetation, root effects and changes in the soil fertility. The indigenous plants with proven potential but neglected or not exploited for their utility need to be introduced in arid farming system. No work has been attempted on this naturalized species management at these difficult sites. It is essential to restore the degraded land through perennial vegetation to check further degradation and to meet requirement of livestock and human. Identifying superior genotypes and development elite planting material may enhances productivity and soil improvement. Attention may need to integrate and evaluate its suitability to develop model agroforestry system with elite genotypes which can enhance productivity efficiently.No report available in the literature about variability and diversity in fruit and seed characteristics observed in the natural populations of *Balanites aegyptiaca* in the Yamuna ravines. It has widely distributed and naturally colonized with higher density at ravine gullies (Photo.1). In order to succeed in Balanites ***aegyptiaca*** domestication, an understanding of genetic variation is prime important. Hence this variability can effectively used for isolation of superior genotypes for inclusion in the large scale practical afforestation or reforestation programme.

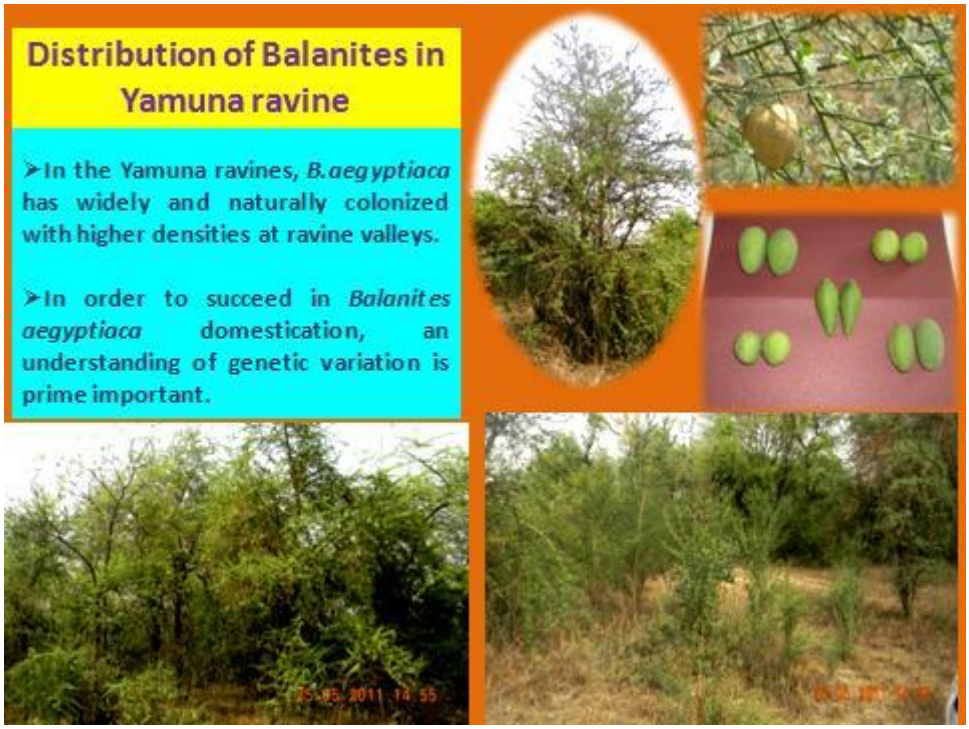

Photo. 1. Naturalized growth and development of *Balanites aegyptiaca* in the Yamuna Ravines

Importance of *B. aegyptiaca* in drylands

Balanites *aegyptiaca* also known as *Desert Date*, it is an important native tree species of the Sudan savannah zone and semi arid tropical region of Asia and Africa. This is one of the most common trees in Senegal. It is also found India, Iran and Pakistan (Amalraj and Shankarnarayan, 1986). The species is at its best on deep well-drained soil at altitudes of between 450 to 600 m above sea level with a rainfall between 200 and 500 mm per annum. *B. aegyptiaca* had been used over thousands of years in the among the arid zone regions of world (Von Maydell, 1986). *B. aegyptiaca* is belonging to the *Zygophyllaceae* or *Balanitaceae*. It can be found in many kinds of habitat, tolerating a wide variety of soil types, from sand to heavy clay, and climatic moisture levels, from arid to sub humid. It is relatively tolerant of drought, flooding, livestock activity, and wildfire. *B. aegyptiaca* has wide ecological distribution; however, it reaches its maximum development as an individual tree on low-lying, level alluvial sites with deep sandy loam and uninterrupted access to water such as valley floors, riverbanks or the foot of rocky slopes. Fruit is 4-5 cm long, green, brown or pale brown with a brittle coat enclosing a brown or brown-green sticky pulp and a hard stone seed. Seed storage behaviour is orthodox; viability can be maintained for 2 years in air-dry storage at cool temperatures or for several years in hermetic storage at 3 deg. C with 6-10% mc. One kilogram of cleaned, extracted seeds, air-dried to 15% mc, contains 500-1500 seeds. The fleshy pulp of the fruit is eaten fresh or dried. The leaves are used as food, the bark as a

substance for fishing and the wood as yoke for draught animals and hand implements. The flesh of the ripe fruit, which is very rich in carbohydrate and vitamins, is eaten, but the tree is mainly important for its nut that is also known as stone (Shanks & Shanks, 1991). This fruit contains 64 -72% carbohydrates, plus crude protein, steroidal saponins, vitamin C, ethanol and other minerals (Abu Al-Futuh, 1983). All parts of the tree have a medicinal uses including fruits, nuts, barks and roots. Balanites *aegyptiaca* is very useful medicinal tree which is widely used for the treatment of various diseases. The leaves and fruits eaten by goats, sheep and camels; thorny branches used for live-fencing. It is widely used as good firewood and charcoal; edible fruit and nuts have 30-40 % of edible oil (Dubey *et al.,* 2011). Both fruits and kernel were widely used livestock feed in many countries during the dry season and drought periods in the dry tropical region. In addition to that one tree can produce up to 100 - 150 kg of fruits per year (Schimdt, and Joker, 2000), and the kernel represents 15% of fruit (Elfeel and Warrag, 2006). It has been experimentally proved that B. aegyptiaca Del possess antioxidant, antimicrobial, anticancer, diuretic, hypocholesterolemic, wound-healing, antiviral, antidiabetic, hepatoprotective, mosquito larvicidal, anti-inflammatory and analgesic, antivenin, anthelmintic, cardioprotective cum antioxidant activity, and antinociceptive properties. Bark, fruits, seeds, seed oil, and leaves of this plant are widely used in folk medicine. Many applications can be summarized such as using of leaves for fodder, branches for fencing materials, fire wood and charcoal making, timber for furniture and constructing huts, controlling soil erosion and competing desert encroachments. In spite of their great potential little attention has been given to these species. Balanites aegyptiaca “soap berry tree; thorn tree, desert date” is an important multipurpose trees species in dry land Asia and Africa. The tree is a potential source of medicines, pesticides, edible oil, animal feed, nuts, soap, and fuel wood. The edible fruits are rich in saturated fatty acids which are used as cooking oil. The fruit also contains Stereoids (Saponins, Sapogenins, and Disogenins) which are used as a row material for industrial production of contraceptive pills and other sexual hormones. In recent years, emphasis of research has been on utilizing traditional medicines that have long and proven history of treating various ailments. The plant seed kernel produces high quality oil that amounts for 9-10 % by weight of the whole fruit. Its seed kernel has high oil content (50 %) whose extraction is economically worthwhile. The oil parameters revealed that the oil composed of long chain fatty acids with high degree of unsaturation, making it a good feedstock for biodiesel production. Balanites aegyptiaca oil may be useful for industrialists that produce eco-friendly soap. Therefore, conversion of the oil to different products will help in domestication of this neglected and underutilized dryland tree species.

Bunderson et al. (1991) in his investigation on agroforestry practices and potential in Western Sudan reported that B. aegyptiaca has attracted attention as a potentially source of medicines, pesticides, edible oil, animal feed, nuts,

soap, and fuel, as well as hard currency export revenue. In western Sudan the species was used as fuel wood, charcoal, timber, ornamental, shade, insecticide, drugs, sand dune fixation, shelter belt and fodder for livestock (Vgot, 1995)

Bunderson et al. (1991) in his investigation on agroforestry practices and potential in Western Sudan reported that B. aegyptiaca has attracted attention as a potentially source of medicines, pesticides, edible oil, animal feed, nuts, soap, and fuel, as well as hard currency export revenue. In western Sudan the species was used as fuel wood, charcoal, timber, ornamental, shade, insecticide, drugs, sand dune fixation, shelter belt and fodder for livestock (Vgot Indigenous fruit trees play a very important role in the livelihoods of rural people, especially for those living in the dry land areas (Von Maydell, 1983), where crop failure often resulted in a poor nutrition of the local population (Maxwell, 1991). FAO (1990) indicated that a number of 18,000- 25,000 wild-collected species are used as food. In many part of Sudan wild plant are common in the normal diet (Gebauer et al., 2002). However, the potentiality and their contribution to farmer livelihood and poverty elevation are not acknowledged. W ith the massive increase in human population, drought and desertification, low and erratic rainfall development of alternative crops to improve the range of commodities is needed (El-Siddig et al., 1999). An example of such species is B. aegyptiaca (L.)Del. Commonly known as desert date and locally known as “Heglig”. The species grow naturally on the arid and semi arid area in East, Central and North part of Africa (Von Maydell, 1983). In Sudan the species was found in different soil type ranging from sand soil, heavy clay soil, to the rivers soil along the water streams. The tree is growing in rainfall ranging from 200-800 mm\annum (Vgot, 1995). Bunderson et al. (1991) in his investigation on agroforestry practices and potential in Western Sudan eported that B. aegyptiaca has attracted ttention as a potentially source of medicines, pesticides, edible oil, animal feed, nuts, soap, and fuel, as well as hard currency export revenue. In western Sudan the species was used as fuel wood, charcoal, timber, ornamental, shade, insecticide, drugs, sand dune fixation, shelter belt and fodder for livestock (Vgot, 1995).

Many authors have reported a great genetic variation on seeds of tropical tree species such as Acacia senegal (El Feel and Warag, 2004), Faidherbia Albida (Ibrahim, 2002), Acacia nilotica (Chhillar et al., 2002), Azadirachta indica (Sidhu et al., 2003). El feel and Warag (2006) studied the variation among nine B. aegyptiaca geographical seed sources in seed morphological and chemical characteristic; they reported a great variation among different seed sources on seed length, seed diameter, size index ratio, shape index ratio, oil content, protein content and the carbohydrates (Table 1). This study aimed to summarizing information on different aspects of Balanites aegyptiaca to stimulate the interest in this valuable tree species.

Natural Genetic diversity in *B. aegyptiaca*:

A through and extensive germplasm exploration survey was undertaken to identify the superior individuals/ genotypes from predominantly naturalized locations of 85 ha of Yamuna ravine land area which it is located inside our ICAR-IISWC, Research farm at Chhalesar in Agra district and it is core part of typical Yamuna ravine. The study site is located at 23^0 52' to 31^0 28' N latitudes and 77^0 06' to 84^0 37' E longitudes and 169 m above mean sea level with high terrain undulated topography. It has humid sub-tropical climate with high variation between summer and winter temperatures. Summers are long, from early April till October, with the monsoon season in between. Cold waves from the Himalayan region dip temperatures across the city in the winter from December to February. The average temperature is 32°C - 47°C in summer; 10°C-15°C in the winter. The average annual rainfall is 550 mm. Fog is common in winter while hot dry winds called loo blow in summer. Soils are generally old alluvial deposits of the middle Gangetic plain. The genotypes were identified and selected based on superior morphometric traits (tree height, basal girth, number of branches, flower and fruit colour, freedom from pest and diseases) by comparison / check tree method. The selected trees are referred as Candidate Plus Trees (Zobel and Talbert, 1984). The selected CPTs were given with the accession numbers like YRBA-1 to YRBA-8 based on the region from which they were selected. The fruit were collected from identified individual plus trees. Five kilograms of mature fruits from each CPT were collected following a random sampling procedure from all the four directions of the crown of each selected tree during the fruiting season. The selected trees were widely spaced between each other to avoid collecting fruits from related trees. Fruits of each tree were kept separate as an open-pollinated family. The details about geographical location and salient variation features of fruit from each CPT were documented as mentioned in the Table 1. Then, CPTs fruit lots were cleaned dried and stored in muslin bags at ambient conditions. All fruit lot was dried under similar temperature and humidity conditions to reach a constant weight. A total of 100 numbers of healthy fruit were drawn from each fruit lot (25 in each replication) and measured for the following five quantative characters viz., fruit shape, fruit colour, Fruit length (cm), fruit breadth (cm), fruit weight (g) with four replications each. The each CPTs fruits were soaked individually in cold water for 3 days and washed several times to obtain the nuts. The fruit and nuts were showing peculiar morphological variation in size, shape colour and weight. He observed genetic diversity suggested its genetic variation between individual trees within location. Determining this genetic variation is very important for improvement and domestication of this species using fruit and seed parameters (Zobel and Talbert, 1984). Therefore, the objective of this study is to assess morphological variation in fruit characters specifically among natural populations in the

rehabilitated forest area which is typically situated in Yamuna ravines and it is main heart of Agra district in Uttar Pradesh. The salient features of the CPTs fruit parameters were presented in Table 1. On the basis of fruit variation among the natural populations of *B. agyeptiaca* in the Yamuna ravines**,** eight phenotypically superior genotypes were identified with given accession numbers viz., YRBA-1, YRBA-2, YRBA-3, YRBA-4, YRBA-5, YRBA-6, YRBA-7 and YRBA-8. The table 1 and photo.2 was exhibits the ambient morphological variation in fruit length (cm), fruit diameter (mm), fruit weight (g), shape, size, colour, fruit end, fruit rind ridge pattern on fruit by horizontal and vertical view. Since the size of the fruit, nuts and kernel are considered to be important parameters in marketing and other utility points. Obviously, the phenotypic variances were ultimately expressing their genotypic variances revealing that the selection on the basis of phenotypic performance can be equally effective to that of genotypic performance. In order to succeed in Balanites *aegyptiaca* domestication, an understanding of genetic variation is prime important. Within the species, there is evidence showing the occurrence of a number of local forms differing in habit, size, quality of the fruit and nut characters. Knowledge of the genetic variation within the species is essential to design a strategy to promote the use and conservation of indigenous fruit trees meant for on-farm cultivation. However, for two decades, the World Agroforestry Centre (ICRAF) and its partner institutions have emphasized to conduct research especially on domestication of indigenous or lesser known fruit trees in dry tropical regions. Several authors also conducted similar study and results were reported for fruit length, fruit diameter and fruit weight in *Populous deltoids* by Varma and Bangarva (2007), in *Emblica officinalis* by Pandey *et al.*, (2008), in Jatropha *curcas* by Rao *et al.*, (2008), in *Madhuca latifolia* by Divakara and Krishnamoorthy (2009) and in *Pongamia pinnata* by Divakara *et al., (*2010). These CPTs could be considered / utilized for hybridization or other tree improvement programmes in this species. Fruit product (size, seeds) quality could be influenced by plus trees indicating that it is necessary to study the high yielding germplasm/ varieties which possessing high fruit quality in order to fetch good prices from market for producers. In this study, the huge variation in fruit characters within populations observed in the present study is a first indication that valuable gains could be made by selection of good varieties. The specie provides very nutritious feed source through leaf fodder and fruit material to wild animals as well as to local domestic animals from nearby villages. This species exhibits highly varied growth, leaf, fruit and nut characters among natural population at this region. This species naturally shows wide variation and high adaptation under this harsh gullied badlands ie.ravines, as a tolerant, productive as well as restorative species to maintain other biodiversity too. Development superior genetic resource on this multipurpose species may

helpful to integrate into several forestry and agroforestry systems. The *B. aegyptiaca* has widely and naturally colonized with higher densities at ravine valleys through root suckers. It plays many imperative ecological roles in this fragile ecosystem especially in soil erosion control. It is hardy species having highly developed dense deep root system enhance soil conservation value to prevent gully expansion.

Table 1. Fruit parameters among Candidate plus Trees of *Balanites aegyptiaca*

Name of CPTs	Location of CPTs	Fruit Shape	Fruit Colour	Avg.Fruit length (cm)	Avg. Fruit Diameter (mm)	Avg. Fruit Weight (g)
YRBA-1	Yamuna Ravines	Oblong	Brown	5.2	18.7	18.5
YRBA-2	Yamuna Ravines	Spheroidal	Pale brown	3.8	20.5	33.4
YRBA-3	Yamuna Ravines	Tapered oblong	Brown	5.6	22.5	25.8
YRBA-4	Yamuna Ravines	Spheroidal	Pale brown	5.5	25.6	19.5
YRBA-5	Yamuna Ravines	Round	Pale brown	3.6	27.5	22.8
YRBA-6	Yamuna Ravines	Spheroidal	Brown	5.8	18.8	29.4
YRBA-7	Yamuna Ravines	Round	Pale brown	3.4	27.5	38.6
YRBA-8	Yamuna Ravines	Round	Pale brown	4.2	28.5	42.5

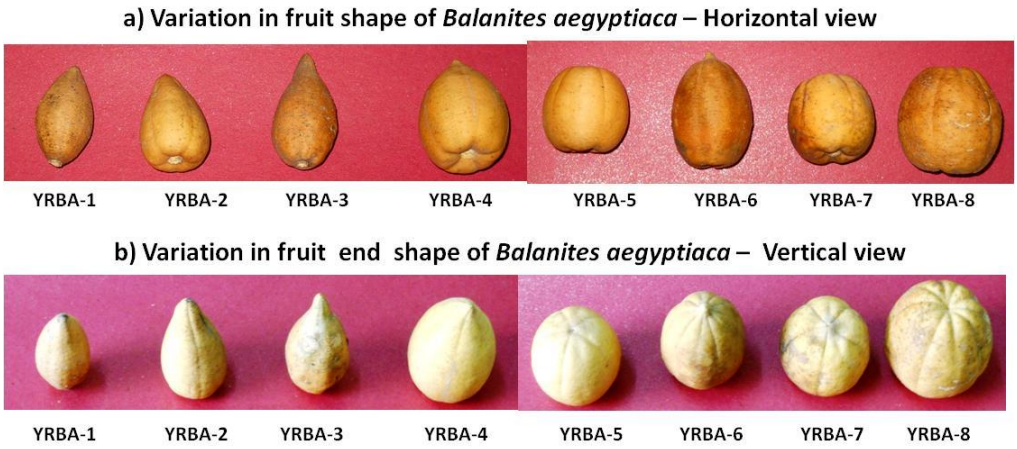

Photo. 2. Variation in fruit traits of *B. agyeptica* in the Yamuna Ravines

B.aegyptiaca - why important in ravine region ???

B.aegyptiaca has widely and naturally colonized with higher densities at ravine valleys. It plays a critical ecological role in this fragile ecosystem.

It is hardy species having highly developed dense deep root system enhance soil conservation value to prevent gully expansion.

Very nutritious feed source through leaf fodder and fruit material to wild animals as well as to local domestic animals from nearby villages.

This species exhibits highly varied growth, leaf, fruit and nut characters among natural population at this region.

This species naturally shows wide variation and high adaptation under this harsh ravinous ecosystem as a tolerant, productive as well as restorative species to maintain other biodiversity too.

Photo. 3: Ecosystem service benefits from *B.aegyptiaca* in Indian Ravine lands

Photo.4 *B. aegyptiaca* -play a vital role in food security and economy of the rural population in African countries

Importance in ravine restoration and way forward

In the Indian ravines, *B.aegyptiaca* has naturally colonized species at ravine valleys. It plays a critical ecological role in this fragile ecosystem. It is hardy species having highly developed dense deep root system enhance soil conservation value to prevent gully expansion. The specie provides very nutritious feed source through leaf fodder and fruit material to wild animals as well as to local domestic animals from nearby villages. This species exhibits highly varied growth, leaf, fruit and nut characters among natural population at this region. This species naturally shows wide variation and high adaptation under this harsh ravine ecosystem as a tolerant, productive as well as restorative species to maintain other biodiversity too. This preliminary study shows the remarkable variation and diversity in fruit and seed coat morphology under ravine lands. Fruit product (size, seeds) quality could be influenced by plus trees indicating that it is necessary to study the high yielding germplasm/ varieties which possessing high fruit quality in order to fetch good prices from market for producers. In conclusion, the huge variation in fruit characters within populations observed in the present study is a first indication that valuable gains could be made by selection of good varieties. It could be considered for successful domestication and exploitation of this drought tolerant

species for mass afforestation/ reforestation purposes. These results are also highlights the potential fruit and nut sizes of *Balanites aegyptiaca* for oil production and animal feed as an agro-industrial material in the resource poor regions. Hence, this kind of basic and natural variation could useful in planning, conservation, domestication or improvement of this species. *Balanites aegyptiaca* had been used over thousands of years in the among the arid zone regions of world. It is also commonly known as *Desert Date*, it is an important native tree species semi arid tropical region of Asia and Africa. The tree is highly valued for its fruits and seeds in African and Arabian countries. Fruit and seed used as important feed material for livestock especially goats during dry season. The seed kernel is rich in oil, protein, minerals and ediblenut as snacks after boiling. A total of eight Candidate Plus Trees (CPTs) of *B. aegyptiaca* were identified to elucidate their variation and diversity from diverged locations of Yamuna ravines of Agra district in Uttar Pradesh. The identified CPTs have huge genetic variation in fruit morphological and other parent tree characters. The fruit shape varied from elliptical, oblong, round in shape as well as different kind of fruit rind ridge pattern at fruit ends. The fruit colour also shows variation ranging from pale brown, dark brown, yellowish brown. Fruit morphological characters of the wild accessions are considered to be the first step in ascertaining genetic variability of the population. Genetic factors may induce and maintain variation in fruit and seed size. Economically, large fruits may be fetch higher price in markets and also preferable because they have reserved high energy to produce larger and more vigorous seedlings with better chances of survival than small fruits and seeds. Finally, highlighting and summarizing information on different aspect of natural diversity in *B. aegyptiaca* to stimulate the scientist interest in this valuable tree species which is of economical importance for rural inhabitants of resource poor dry regions in the naturalized countries. The high tolerance of this desert date tree is adapted to extreme dry and hot climatic environment which is useful in many economic and ecosystem functions like soil erosion control, Soil carbon litter addition, bee forage plant for honey support and potential carbon entrapment in dry zones (Photo-3). Underutilized fruit trees play a vital role in food security and economy of the rural population in a number of African countries (Photo.4). Beside this significance, importance of this underutilized plant in honey bee support which enhances nearby agricultural farming land productivity through pollination support, ensure food security and livelihood of the local population. However, little information is available about propagation and domestication of this valuable tree species; therefore, studies are needed for sustainable use of underutilized fruit trees i.e. *Balanites aegyptiaca* of dry regions. Hence, this study envisaged that fruit parameters could be used as selection criteria for early selection plus trees. The existing substantial amount of genetic diversity

in identified CPTs can be utilized and it should be considered in conservation, domestication and improvement plans of this tree for commercial cultivation, hybridization, genetic resource conservation and further genetic improvement programme. This highly varied magnitude of genetic diversity among the plus trees of *Balanites aegyptiaca* offers excellent scope for exploration, development and popularization of high yielding genotypes for cultivation through agroforestry and other afforestation programme.

Rhizobacteria: unveiling the key players in nutrient cycling and soil fertility

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Abstract

Nutrient cycling and soil fertility are vital components of ecosystem health and sustainable agricultural practices. In recent years, the role of rhizobacteria, a diverse group of microorganisms residing in the rhizosphere, has garnered significant attention for their profound impact on these crucial processes.It delves into the intricate mechanisms through which rhizobacteria form symbiotic associations with plants, including root colonization and biofilm formation. These associations facilitate nutrient acquisition, as rhizobacteria contribute to the mobilization, solubilization, and mineralization of essential elements, such as nitrogen, phosphorus, and micronutrients.Harnessing the potential of rhizobacteria presents an exciting avenue for promoting soil fertility and enhancing the resilience of agricultural systems in the face of environmental challenges.

Key words: Rhizobacteria, Biological Nitrogen Fixation, soil fertility

Introduction

Rhizobacteria, a varied collection of soil microbes, are essential for the nitrogen cycle and the preservation of soil fertility. These advantageous bacteria settle in the rhizosphere, the area of soil that is influenced by plant roots, and work in symbiosis with the plants. Rhizobacteria improve the availability of nutrients, encourage plant development, and add to the general wellbeing and productivity of soil ecosystems through a variety of methods. In this article, we'll examine the varied contributions that rhizobacteria make to soil fertility and nitrogen cycling.

Production of plant growth-promoting substances

Rhizobacteria produce a variety of enzymes, phytohormones and siderophores, that aid in the growth of plants (de Andrade et al.,2023). Auxins and cytokinins are examples of phytohormones that promote root development, improve nutrient uptake, and control a number of biological functions in plants. Iron is chelated by siderophores, which make it more available to plants. Additionally, rhizobacteria generate enzymes that disintegrate intricate organic materials and liberate nutrients for plant utilization. Together, these elements support plant development, raise nutrient availability, and raise soil fertility.

Nutrient solubilization

Essential nutrients like nitrogen (N), phosphorous (P), and iron (Fe) can often be found in forms that are unavailable to plants, but rhizobacteria are skilled at solubilizing and mobilizing these nutrients. Some rhizobacteria species have the capacity to create siderophores, enzymes,

and organic acids that degrade complex substances, chelate nutrients, and aid in their uptake by plants (Pandey et al., 2023). One such instance is the release of organic acids by phosphate-solubilizing bacteria (PSB), which breakdown phosphate minerals and liberates bioavailable phosphate ions. Rhizobacteria make ensuring that plants have access to the necessary nutrients for development and growth by improving nutrient availability.

Biological nitrogen fixation

By engaging in a unique process known as nitrogen fixing, these bacteria also aid in the biological cycle of nitrogen (Ladha et al., 2022). Nitrogen-fixing bacteria, such *Rhizobium*, *Azotobacter*, and *Azospirillum*, have the singular capacity to change atmospheric nitrogen (N_2) into ammonium (NH_4^+), a form of nitrogen that is useful to living things. This activity takes place inside specialized nodules that develop on the root system of leguminous plants. In addition to promoting the host plant's growth, the fixed nitrogen enriches the soil and makes it more fertile for nearby plants. Rhizobacteria are essential for preserving soil fertility and minimizing the necessity for artificial nitrogen fertilizers by turning naturally occurring nitrogen into a form that is useable by plants (Daniel et al., 2022).

Disease suppression and stress tolerance

Rhizobacteria have defence mechanisms that help plants withstand stress and decrease the chances of infection. They have the capacity to create antimicrobial substances that stop the spread of plant pathogens and shield plants from pathogen attack (Begum et al., 2022). Rhizobacteria can also cause systemic resistance in plants, triggering their built-in defence. Rhizobacteria maintain the health and vigour of plants by lowering the incidence of disease, which improves soil fertility. By boosting the absorption of nutrients and water and root system development, these bacteria also help plants tolerate abiotic stress like salinity, drought and heavy metal toxicity.

Breakdown of organic materials and the resulting release of nutrients

Additionally, these bacteria also contribute to the preservation of soil structure and the breakdown of organic materials. They aid in the production and stabilisation of soil aggregates, increasing the porosity of the soil, water infiltration, and aeration, by generating polysaccharides along with other extracellular chemicals. Rhizobacteria also actively take part in the decomposition of organic materials, releasing vital nutrients and assisting in the production of humus. Rhizobacteria break down organic materials, increasing the soil's nutrient content, capacity for cation exchange, and encouraging long-term soil fertility (Romeh, 2022).

Conclusion

In order to maintain ecological balance and agricultural output, rhizobacteria's function in nutrient cycling and fertility of the soil is of utmost importance. These helpful bacteria aid in the mobilization of nutrients, the fixing of nitrogen, the eradication of disease, and the breakdown of organic matter. By utilizing rhizobacteria, we may lessen our reliance on synthetic fertilizers, lower environmental pollution, and enhance the general sustainability and health of our soils. Rhizobacteria-based technologies have enormous potential for advancing

sustainable agriculture and safeguarding our planet's resources for future generations, and they merit further study and use.

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An industrial perspective on bamboos

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Bamboo, the magnificent grass (Poaceae) species growing in tropics and subtropics, have many uses, providing a vast range of sustainable products, livelihood options and ecosystem services. An old Asian proverb that states, "A man is born in a bamboo cradle and goes gone in a bamboo coffin," serves as an example of how bamboo has been used historically. With bamboo, everything in between is possible. It is the material of the future and a most versatile naturally engineered material used in various sectors.

The natural resource bamboo is a wonderful gift from nature that benefits the sociocultural, physical, and economic conditions. They make excellent materials for carbon sequestration. Because of its adaptability, high strength-to-weight ratio, and parity with steel, bamboo is a species of significant commercial value and is employed in a wide range of industrial applications across the globe.

Many industrial applications for bamboo exist, including the production of food, charcoal, wood substitutes, pulp and paper products, as well as small-scale businesses. Bamboo is frequently used as a substitute for wood and other industrial raw materials in both traditional and modern cottage industries. Bamboo is more resistant to decay and warping brought on by moisture compared to many other types of wood. Moreover, bamboo is naturally UV-resistant. This makes it perfect for everything from clothing to floors.

Species like *Bambusa bambos, Bambusa balcooa, B. cacharensis, B. polymorpha, B. nutans, Dendrocalamus asper, Dendrocalamus hamiltonii, Thyrsostachys oliveri,* and *Meloccanna baciferra* are widely used in many industries for construction purposes and various end uses because of their many properties, which include strength, smoothness, straightness, lightness, and durability.

Application of bamboo species in construction sectors

Common species like *Dendrocalamus strictus, Bambusa balcooa, Bambusa bambos, Bambusa tulda, Dendrocalamus giganteus, Melocanna baccifera,* and *Dendrocalamus asper* are used frequently in various construction sectors in India for structural purposes because of their typical anatomical characteristics that make them suitable for use in different structural and non-structural applications.

Bamboo is the ideal building and construction material in Africa, Asia, and South America because of its incredible strength and flexibility. Because of the thickness of the fibres in the sclerenchyma tissue, bamboo, which has microfibre structures with lignin-carbohydrate complex (LCC) content, is stronger than concrete and steel by weight.

Due to its higher tensile strength than mild steel and ability to withstand compression twice as well as concrete, bamboo may easily replace materials used in the construction of wind turbines, homes,

drainage pipes, and roads. Compared to the majority of industrially used construction wood types, bamboo has a tensile strength that is three times greater—160 N/mm2.

The market for bamboo goods in India is divided into four key categories: region, end-user industry, species, and application. It is possible to separate many species for the market, including *Dendrocalamusstrictus*, *Bambusatulda*, and *Bambusabambos*. Due to its wide-ranging use in the building sector, the *Bambusatulda* species is predicted to dominate the market. In India, the demand for bamboo products is estimated to increase gradually throughout the anticipated time range. The market for bamboo products in India is large due to its widespread use as a building and construction material in Africa, Asia, and Latin America.

Bioenergy production via bamboo species

For the global energy sectors, sustainability and resource diversification provide a significant challenge. Finding renewable resources with a steady supply is therefore of the utmost importance. Bamboo is a renewable source of non-food biomass and lignocellulosic material with a lot of potential for application in the energy sector.

Numerous research have been conducted on several kinds of bamboo, and the results show that bamboo possesses many of the same advantageous traits as other woody biomass, suggesting that bamboo may one day be used as a fuel (Table 1)

Table 1. Fuel characteristics of some bamboo species (Scurlock et. al., 2000; Sritong et al., 2012)

	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)	Higher heating value (kJ/kg)
Bambusa deecheyama	14.30	3.70	63.10	18.90	15.700
Dendrocalamus asper	5.80	2.70	71.70	19.80	17.585
Phyllostachis nigra	13.62	0.41	72.27	13.7	19.27
Phyllostachis bambosoides	9.54	0.53	75.55	14.38	19.49
Phyllostachis bissetii	21.97	0.9	64.99	12.14	19.51

Bamboo based handicraft sectors

One of the oldest crafts that man is aware of are bamboo crafts done by hand. It is routinely carried out throughout much of India. India is a well-known producer of bamboo products; therefore its craftspeople have taken care to produce gorgeous functional goods. These products are meant to be used at home. In modern times, a variety of ornamental things are also made from cane and bamboo. In India, thousands of people are employed full-time in the bamboo/cane industry. The creation of ornamental things is another endeavour for these artists. Items made with bamboo by hand have a great decorative value. These bamboo goods are also helpful, which is an added benefit. Products made of bamboo include baskets, handbags, chairs, boxes, and teapots.

Some of the important bamboo species used in the handicraft industry is *Bambusa bambos, Bambusa nutans, Bambusa pallida, Dendrocalamus asper, Dendrocalamus strictus, Guadua angustifolia, Dendrocalamus stockii*

Bamboo for pulp and paper

Similar to wood pulp, bamboo pulp is a type of pulp that is mostly produced from moso bamboo, Phyllostachys pubescence, and Sinocalamusaffinus through sulphate or soda processing. It is the perfect raw material for making paper since it closely resembles coniferous wood, which is the best choice for pulp manufacturing, in terms of both fibre form and chemical composition. Bamboo has high cellulose content, a thin, solid fibre with excellent flexibility, and a fibre length in between that of hardwood and softwood.

Conclusion

Bamboo can be used as a wood substitute and a versatile forest product that is crucial to both the residential and industrial economies of the world because it is a biodegradable, natural, renewable material with similar properties to many hardwood and softwood species. Bamboo and products derived from it are utilised for a number of indoor and outdoor functions due to its accessibility and versatility. Bamboo is one of the most highly renewable resources in India's socioeconomic-cultural-ecological-climatic-and-functional setting, with more than 1,500 known uses. In addition to being a component of consumer items, it has immense potential as a raw material for industry.

Among the many industrial applications for bamboo are food production, wood replacement, pulp and paper, handicrafts, medicines, cottage industries, bioenergy, the construction and housing sectors, and the production of charcoal. Bamboo is frequently used as a substitute for wood and other industrial raw materials in both modern industrial and traditional cottage industries. Bamboo lignocellulosic composites are currently on the market. Different bamboo composites and laminates are now being developed; they offer strong, long-lasting, economical, and environmentally friendly alternatives to commonly used timber species, which may help ease the strain on existing forests and plantations.

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Role of artificial intelligence in forest conservation

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The wild forest fires that burn down entire landscapes causing immense damage to the environment, animal life, human lives living in the vicinity and, of course, the climate at large. In the last decade, 36 per cent of India's forest cover has been under the radar of catastrophic forest fires. While the fire is just one part of how forests are shrinking, deforestation, man-animal conflict, poaching, and developing villages and townships in and around the forest area are some of the many other reasons for forests to be in trouble.

Traditionally forests were under the surveillance and supervision of the local and tribal people who took pride in taking care of the land. But, with the changing environment and developing economy, they have been unable to keep up and foresee circumstances. Even forest authorities and officials have been unable to keep mishaps at bay, and it is unreasonable to even expect a few people to collectively manage and monitor such a huge forest. It is humanly impossible.

As a result, poaching has become a full-time job for criminals. They have become tech-savvy and the efforts to curb wildlife crimes need pace and advanced technology. Man-animal conflict is another area causing immense trouble to both animals and humans. Controlling these unforeseen accidents also requires technological intervention. This is where Artificial Intelligence or AI is making a difference.

Artificial Intelligence is one technology which is designed to help human beings. AI-enabled robots/machines can self-perform tasks, self-learn and improvise on the go, allowing human beings to do better and more innovative work. In the forest conservation context, AI is helping humans

by making identifications of animals, their movements, and unexpected events easy and prompting the authorities to take action. This reporting happens in near real-time and provides multi-spectral reconnaissance and surveillance of the forest.

AI-enabled aerial drones, infra-red cameras, real-time monitoring devices, RFID tags, and GPS geo-location for surveillance are some technologies used for wildlife conservation worldwide. In India and globally, AI-loaded robotics and drones are being tested in forests to understand various use cases for protecting wildlife and the forest.

In the case of a wild forest fire, AI-enabled systems and machines can detect the

possibility of a fire. The system can be fed with data on sensitive and fire-prone areas and how to identify the possibility of an upcoming disaster. In case of an unrelated activity in those areas, the system can ring off an alarm by sending notifications to the authorities, who can immediately take preventive actions. This will save time, natural resources and tons of money. Forest tourism can also be monitored in similar ways.

Some other relevant use cases can be fighting modern-day threats, including unauthorized deforestation, human encroachment, trespassing, smuggling, wildlife poaching, mitigating man-animal conflict, tracking animal migration, and wildlife tourism. All these issues can be dealt with AI-powered drones. A drone flying over the area could detect a threat or a breach. So, if a drone alerts authorities about human movement in a certain part of the forest and the forest officials mark that as risky or not a cause for concern, the drone learns that and acts accordingly. If any human intrusion is found in restrictive parts of the forests and those are red-flagged, the system learns to identify who is allowed, where, when, what time of the day, and for what kind of activity and prompts the concerned departments.

Man animal conflict and illegal activities in forests need technological intervention. From identifying areas for animals that can be a threat to their lives to mapping out threat zones for illegal activities, automated technology can be used to mitigate the risk.

AI plays a critical role in facilitating forest conservation. From addressing conflicts to alerting landscape changes to unmasking illegal activities, AI can be leveraged to get through different demanding challenges. It can be used to identify felonious people, activities, traps, identify drivers of conflict between animals and villagers and even use the predicted conflict as input for designing an optimal policy. The more this technology is deployed on the ground level, the better results can be expected with minimum human intervention.

Despite a wealth of statistics about the value of our natural resources, we are essentially flying blind when it comes to their current state and how to best protect them. To fight climate change more effectively, while also feeding a growing population, protecting our ocean and freshwater resources, and stemming a global loss of biodiversity, we must close that information gap, and do so in a hurry.

Agriculture is the world's largest industry, employing more than 1 billion people and generating over $1.3 trillion worth of food annually. But food production is growing more difficult, as arable land continues to decline, extreme weather wreaks havoc on predictable growing seasons, and climate change lowers the nutritional value from what is harvested. Our other land-based natural resources, such as forests, are in a similar state – forests shoulder the needs of 1.6 billion people, yet reports indicate we are losing 18.7 million acres a year.

This represents more than just a loss of natural resources, ecosystems and biodiversity, though that's bad enough. Our

current agriculture and land-use decisions are directly contributing to climate change, accounting for nearly 25% of the world's total greenhouse gas emissions. Agriculture is one of the biggest drivers of deforestation, which is one of the top three anthropogenic sources of greenhouse gases – followed closely by agriculture itself.

Managing these resources more effectively improves the well-being of everyone on the planet and also has the potential to improve the planet itself. This presents an incredible opportunity – better management of our ecosystems and land could help feed a growing population, while substantially lowering carbon emissions. However, to act on that opportunity, we need a clearer picture of the current state of the planet's natural systems; how they are changing and what the most effective intervention strategies are. Increasingly, this information gap will be filled by AI-enabled solutions.

Forest management is a good example of how technology-first approaches can quickly deliver results. Conducting a forest inventory hasn't changed much from the statistical sampling approach first introduced in the Nordic countries in the early 1900s. Teams go out into the woods, armed with tape measures, pencils, and a pad of real paper, not a device. They measure the diameter, height and species of each tree in many small "sample plots" to estimate what's in the forest as a whole.

However, there are start-ups devoted to finding better ways to do this inventory. SilviaTerra, an AI for Earth grantee, came up with a software-based approach after becoming frustrated with the status quo while at Yale School of Forestry. Now, their software can assess forests using satellite imagery and machine learning. The algorithm, powered by AI, greatly reduces the amount of fieldwork needed to accurately assess forests and is the vanguard of a new generation of "precision forestry". Their goal is to build a data library and powerful AI tools that can provide an up-to-date map of US forests for the first time in history, with detailed information about each tree. This kind of information enables data-driven environmental management for biodiversity, carbon sequestration, and many other ecosystem services provided by forests.

Work by AI for Earth researchers at Columbia University sheds even more light on why accurate, detailed, and up-to-date information is important. Dr Maria Uriarte, an ecologist, and Dr Tian Zheng, a statistician, have been studying the impact of extreme weather on forests and their re-growth patterns, with an eye towards the impact this has on carbon sequestration abilities – shorter, younger and less dense forests are less effective than older, denser areas. She recently took a team to Puerto Rico to assess the damage to the forests following Hurricane Maria. Uriarte and Zheng, both affiliated with the Data Science Institute at Columbia, will eventually use the collected data, with the remote-sensing images and measurements, to come up with a detailed estimate of the loss from the storm. Without current baseline data and a forward-leaning view of what the forest inventory may be in the future, planners may undervalue forests, or countries may over-value sequestration abilities.

AI can be a game-changer because taking actions are easier and more effective – and less vulnerable to politicization – if we know what is happening on Earth, when and where. The speed of innovation is one of the

few things keeping pace with climate change. Harnessing the power of AI to monitor the impacts of our current land use practices and to model scenarios means that, perhaps for the first time, we can have the right information at our fingertips to more effectively and sustainably manage our lands, watersheds and ecosystems.

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